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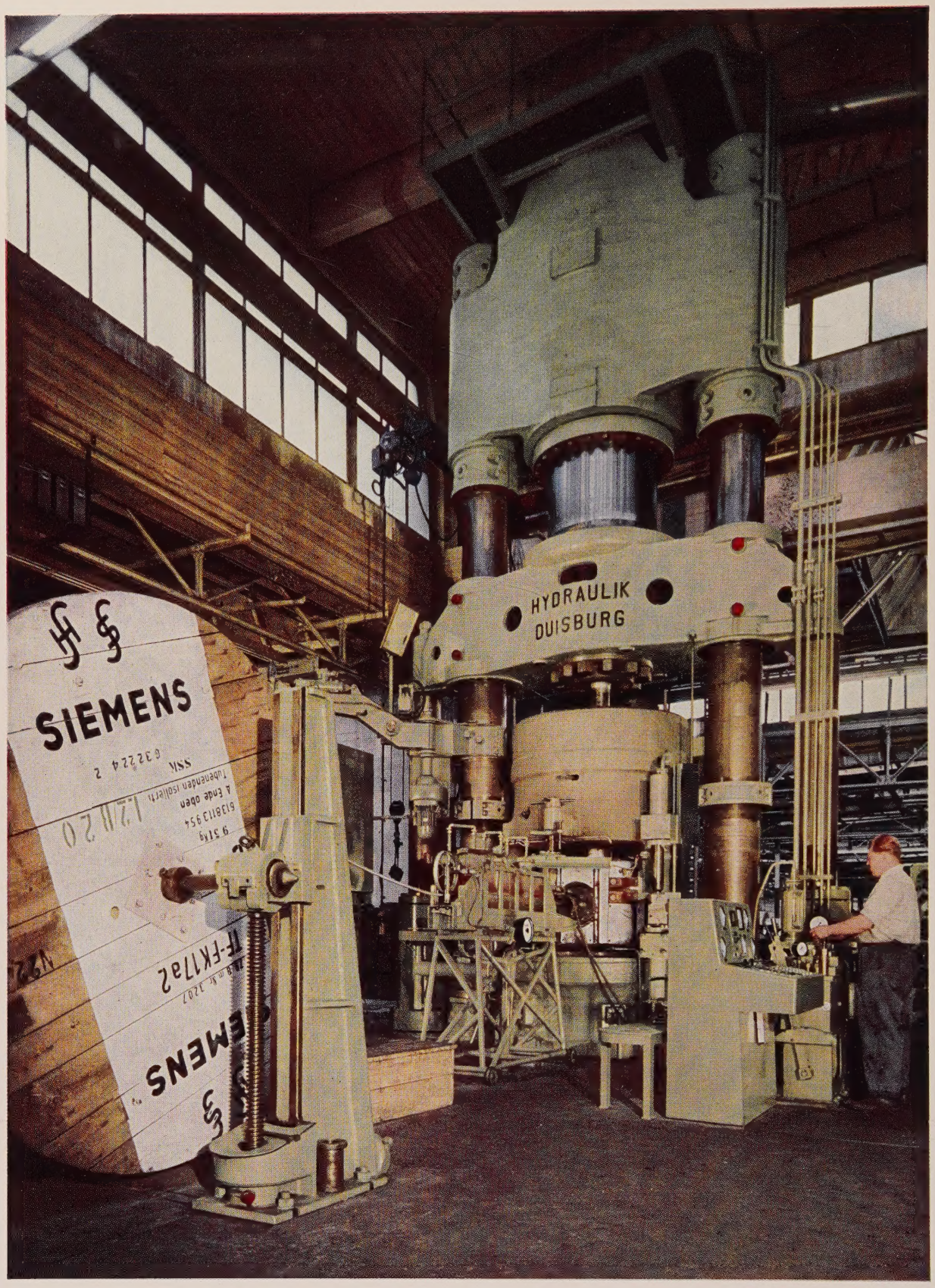

Continuously operating 3,800-ton aluminium sheath extruding press
in the Siemens-Schuckert cable works (Kabelwerk) in Berlin

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Data Reduction by Data Processing

By Ernst Weber

The efficiency of a technical process is determined on the one hand by the machines and appliances used, on the other hand by man and the organization of man power. As to the development of machinery, there is no end in sight yet, while human intervention in the performance of a technical process is restricted within rather narrow limits. Nevertheless, man will always remain the center of every production process, be it ever so automatized. His experience plays an irreplaceable part, and it is one of the tasks of measuring art to preserve and deepen the practical experience of man. More than any machine, man possesses the faculty to select data from a variety of informations according to their notion. Man has intellectual power, but he can process less data than the machine which has none. The performance of a technical process requires that information contents should be continually linked together. The higher the level of these correlations, the greater are the difficulties opposed to their realization, and the more is it required to have recourse to other magnitudes and, in particular, to experience.

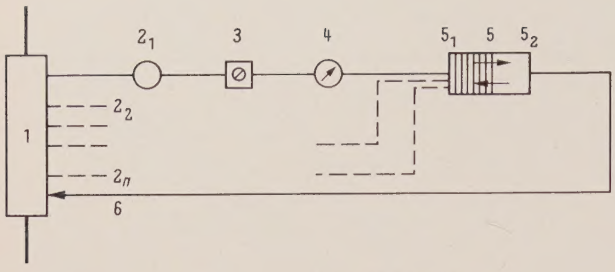
This statement touches upon the basic problem of data reduction. Fig. 1 shows, by way of illustration, the chain of transmission involved in the measurement of a magnitude during a technical process. The information supplied by the sensing elements is made known to the operator via transducers and visual signalling means. These latter may be either indicating or recording instruments, or even simple pilot lamps. The perception of the information starts a most complicated initial data processing action. Sensations develop in the brain, opinions are formed, and the importance of the test reading for the performance of the technical process must be realized. As a final result, human intervention influences the process. Up to the moment of its perception, the information should be transmitted with as little loss as possible. Data processing proper commences with the interpretation of the test readings.

The decision as to whether it is required to intervene in the process and how this intervention should take place is affected by some uncertainty. The more informations are received through the measuring instruments, and the more convenient the form in which they are presented, the smaller will be the degree of uncertainty. The additional information needed to eliminate the residual uncertainty decreases in the same measure. The information rate to be processed by the operator at the end of the chain of transmission is considerably smaller than the information rate at the commencement of the chain. Hence, the purpose and problems of data reduction by data processing may be explained as follows:

As far as possible faultless transmission of the information needed for a decision

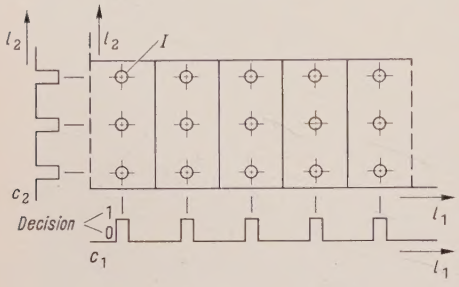
Coding of the information for adapting the residual information rate to the receptivity of the human brain (semantic coding).

The above considerations suggest the question what maximum amount of incoming information can still be dealt with by man. Experiments have proved that man can handle a true rate of information of aurally received or spoken information of up to 8 bits per second [1, 2]. This means that speaker and listener must both make their choice between $2^8 = 256$ possibilities per second. Language, however, is the means of communication of which mankind has the most perfect command. The necessary combination of the numerical values indicated by measuring instruments with other data is considerably more difficult. Researches and investigations carried out in existing control rooms have shown that, on an average, an information rate of not more than 1 bit per second (mostly considerably less) can still be safely handled by an operator.



1 Process
2_1 to 2_n Sensing elements
3 Transducer
4 Indicator
5 Receiver (operator)
5_1 Perception
5_2 Sensation, interpretation
6 Influence upon the process

Fig. 1 Transmission chain of a measurement



I Instruments c_1, c_2 Signal pattern for l_1, l_2 l_1, l_2 Locus co-ordinates

Fig. 2 Switchboard represented as a locus-dependent signal function

Data Reduction During the Transmission of Measured Variables

The operator in a control room is entrusted with taking the necessary readings on the measuring instruments. For this purpose, he is obliged to look up and identify certain instruments, one at a time. Hence it follows that the locus co-ordinates of a plane (the switchboard) or of a space (if, e.g., measuring instruments are additionally arranged on a desk, as shown in Fig. 2) will initially serve as information carriers. Such an arrangement has an information volume of a structural capacity dependent on the number of measuring instruments and their arrangement [3]. The flow of informations takes place according to a fixed schedule since the arrangement of the instruments remains unchanged. Therefore, the idea plainly suggests itself to charge a machine with the task of locating and identifying the individual instruments. As soon as an instrument is located, its indication must immediately be read. The reliability with which the right instrument is correctly read is largely dependent on the observer. His physical condition, diversion of his attention, disturbances, and the time required for taking the readings are influential factors.

While a reading is being taken, the analog indication of a measuring instrument is transformed – with the aid of its scale – into a numerical value. This transformation is liable to introduce many errors, and experiments have proved that direct reading of numerals will cause appreciably less errors [4]. This fact is due to data reduction which considerably reduces the trouble of taking readings. The analog-digital converters used for digital measuring methods [5] reproduce the output values of the transducers with greater accuracy and much quicker than any operator could do. The operation of binary counters [5], used for quantity counting, is a particularly impressive example of data reduction. A whole 24-hour record of the flow, comprising a maximum of approximately 300,000 bits, is replaced by a single number containing only 6 or 7 bits of information at an accuracy of ± 0.5% [6]. This method of data reduction has been used for developing a data-processing system designed to facilitate energy accounting [8].

In this connection, it seems opportune to point out the difference between digital and analog indication of a measured value. A digital indication offers less information than an analog indication does. The analog instrument, e.g., also yields information concerning the measuring range. If a record is at hand, even a portion of the previous history of a process is disclosed. This fact is also the reason why, despite the introduction of digital measuring methods, control rooms equipped with indicating and recording instruments cannot be dispensed with. An instrument which automatically reads the information contained in a record, thus effecting a data reduction, is described in this issue [7].

Semantic Coding

The best-known digital semantic-coding device is the data logger [9]. The data reduction manifesting itself in

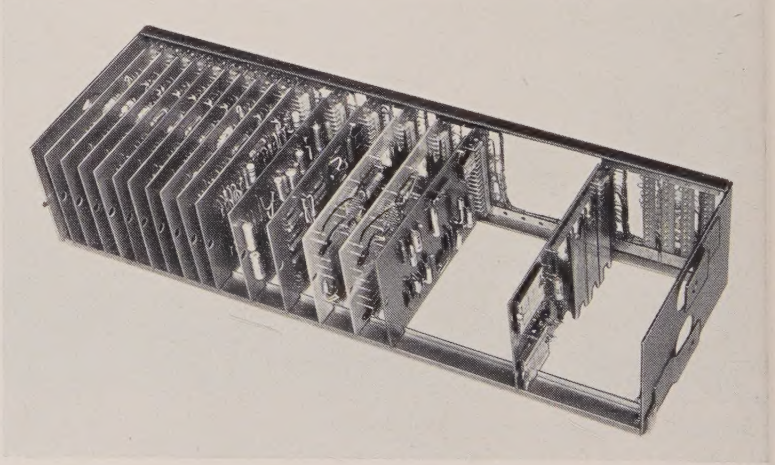


Fig. 3 Binary counter with transistors and magnet cores

the log-sheet printed by this instrument is due to the fact that it meets the requirements as to digital representation and clear arrangement of the data facilitating the evaluation. Moreover, relations to other data and variables can be printed on the log-sheet. Off-normal checks with adjustable reference levels [8] is the simplest semantic coding method enabling the direction and magnitude of a deviation from the desired value, and frequently also the reason for this deviation, to be disclosed. With the aid of the first four rules of arithmetic and simple computing devices, a plurality of variables can be condensed to a few physically or technically impressive and conceivable data. Hence, the resulting table will contain only a small number of so-called master figures [8]. Consequently, the operator gains time, so that he may take decisions on the strength of these figures, without undue haste. Although the computers used for calculating such master figures are not of the integrating and differentiating type, the above-described simple method of data reduction by data processing yields valuable results for the management of technical processes.

Design of Digital Measuring Equipments

The structural elements used are adapted to the continuous decrease of the information rate from the measured variable to the master figure. At the input, electronic members mostly predominate, while electromechanical elements, such as protective-gas contacts [10] and relays, are preferably used at the output. Binary counters, e.g., connected at the input, which are frequently required to operate at a considerable speed and must withstand severe stresses, are equipped with transistors and magnet cores as shown in Fig. 3. Fig. 4 shows a complete installation with both electronic and relay-operated units.

Selectors, arranged in the form of a matrix according to Fig. 5, are particularly suited to hunt for, and identify, the outlets of the transducers because they can be easily adapted to any number of data and their numerical values, and may, moreover, be used to advantage for the programming of digital installations. For selecting the variables, noble-metal, quick-acting relays [11], which are also used for controlling the matrix, are provided at the points of intersection. If thermoelectric voltages are to be selected, noble-metal quick-acting relays, together with a further relay featuring a maximum interference voltage of only 3 microvolts, are accommodated in a common assembly as shown in Fig. 6. The input variable for controlling the selector being the address of the desired variable is mostly automatically scanned within the scope of the whole installation.

The problem how to represent a metrological information in such a way that its importance for a technical process is brought into special prominence, has only recently been clearly realized and solved. The fortunate

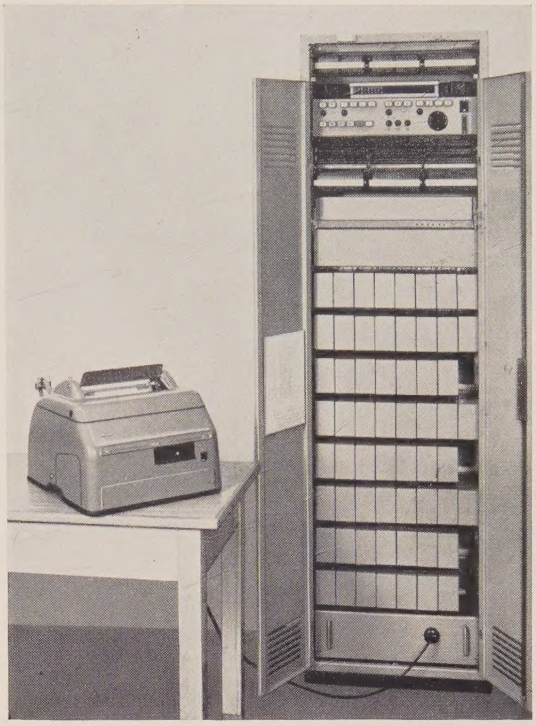
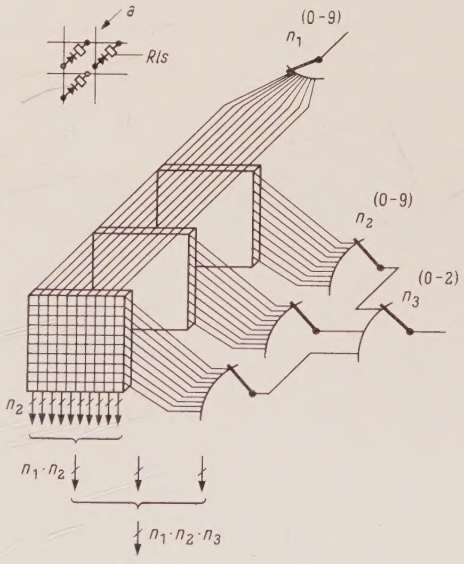


Fig. 4 Data logger, mixed construction with electronic and electromagnetic units

combination of analog and digital measuring technology enables measuring equipments to be designed which possess a formerly quite inconceivable flexibility in their organization. An analog measuring instrument is designed for a specific purpose. In the case of a data



n_1 (0-9), n_2 (0-9), n_3 (0-2) Input selectors (noble-metal quick-acting relays) for $10 \times 10 \times 3 = 300$ outlets
a Section of the matrix
RIs Selector relays

Fig. 5 Diagrammatic view of a matrix for selecting the outlets of transducers

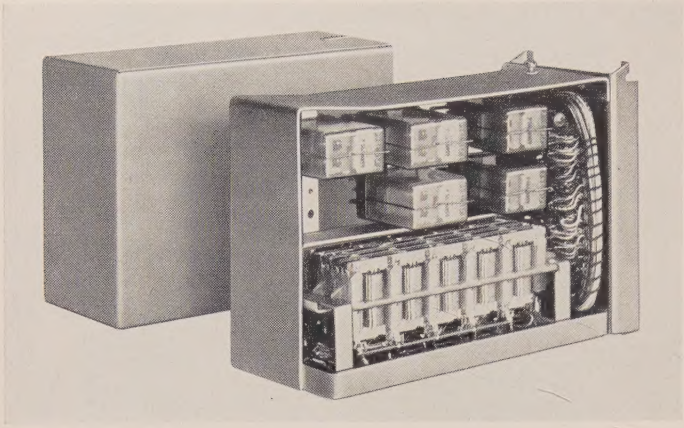


Fig. 6 Matrix assembly for selecting thermoelectric voltages

processing installation containing both analog and digital subassemblies, however, logical and pragmatic relations govern the layout. Owing to the program, which is easily variable, the installation becomes a system whose organization can be adapted to any problem that may possibly present itself.

Thus, the way for an entirely novel development in the control of industrial processes is prepared. Similar to the invention of the electric motor which, revolutionizing machine-tool engineering, has brought about a complete change in the ideas governing production, data processing will initiate a new departure in plant management. It would be a wrong policy to design data-processing equipments merely for the purpose of replacing manpower. Industrial development urgently calls for manufacturing more and more and better and better products. Such a progress in quantity and quality, however, is impossible if the old means and methods of production are retained. The higher a system is organized, the more important the exchange of information will be. Without data reduction, however, the vast amount of necessary informations cannot be handled any longer. Data reduction by data processing is not a question of convenience but has become a necessity. While nowadays already the means for solving the various problems involved are mostly available, the chief point is to recognize these new problems, to formulate them, and to have the courage of taking a new line. In his well-known book "The Human Use of Human Beings" NORBERT WIENER says that the "know how" will offer no difficulties, but the "know what" is a problem which remains to be solved.

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An Electronic Diagram Reader Facilitating the Evaluation of Charts

BY HANS BREUNIG AND HANS KÜRNER

Recording instruments are used in all branches of industry wherever it is required that the instantaneous value and trend versus time of the variables should be available at any time, thus enabling important informations to be gained already in the course of a process. Moreover, the information contained in the records can be profitably utilized for the purposes of works economy, planning, and statistics by being subsequently evaluated.

Furthermore, recording instruments are used wherever it is desirable to store variable quantities in the form of curves. The graphs are evaluated at a convenient later date in order to determine, e.g., the interrelation between random-type phenomena and their causes subject to statistical laws.

The evaluation of the curves, which is mostly carried out at a central place, is a very laborious operation if done with care. For this reason, large plants have special evaluating offices for enabling the great number of graphs to be processed. If the evaluation is omitted, the information contained in the records will get lost. To avoid this, a diagram reader (Fig. 1) operating fully automatically and, thus, considerably reducing the evaluating costs, has been developed by the Wernerwerk für Meßtechnik.

Evaluation of Charts According to Different Criteria

The evaluation of recorded graphs always involves a data reduction[1], a great number of values being condensed into a smaller number according to their notions. These data, derived from a multitude of individual values, yield a clear survey, and a correct judgment can be formed of the phenomena under test. When evaluating the recorded functions, the following criteria are of particular interest (Fig. 2):

The integral of the function obtained by planimetering the area below the trace. The quantity, e.g., is obtained as the integral of the flow, and the electrical energy as the integral of the power.

The mean value of amplitudes for certain periods of time, e.g. the mean value per hour resulting from observations covering a month or a year.

Fig. 1 Electronic Diagram Reader

The probability density obtained by measuring the frequency of occurrence of certain amplitudes or amplitude ranges.

The probability distribution obtained by measuring the frequency of occurrence of all amplitudes or amplitude ranges lying between preset levels.

Basic Design of the Diagram Reader

The development of the Diagram Reader was chiefly governed by the following considerations:

It should be possible to evaluate at option strip charts having a useful width of 60, 100, or 120 mm (2.4, 3.9, or 4.7 in.) and a length of up to 30 m (98 ft.).

Curves traced by both continuous-line recorders and dotted-line recorders should lend themselves with equal ease to being evaluated. A colored chart graduation should not interfere with the evaluation. The development work shall first deal with the evaluation of single-curve records only.

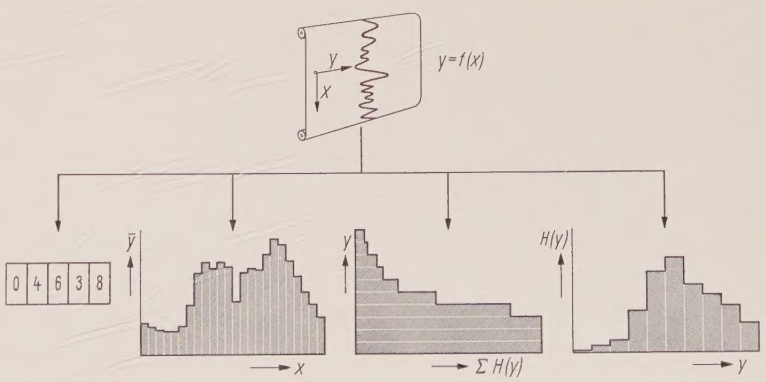
An evaluation should involve the simultaneous determination of the integral and of either the probability density or the probability distribution.

The individual values should be grouped in up to ten adjacent, nonoverlapping amplitude ranges. It should be possible to choose the widths of the individual ranges at option.

It should further be possible to evaluate either whole chart rolls or any chart portions covering selectable periods of one hour or more. For these charts, paper speeds of 10, 20, and 60 mm/hr (0.4, 0.8, and 2.4 in./hr) must be considered.

The time required for evaluating a record should be reduced in the ratio of at least 1 to 3,600 referred to the recording time, i.e., if a graph has taken one hour for being traced, it should be evaluated within one second at the most.

Fig. 3 shows the principle of operation of the Electronic Diagram Reader. The chart moves at a uniform speed. A portion of it is illuminated and projected, via a lens system, onto a television camera tube (Vidicon). An electron beam then scans the image of the diagram on the image plane of the Vidicon tube in the direction of the ordinate, thereby converting the amplitude of the curve



y Amplitude $\bar{y}$ Mean value of amplitudes $\Sigma H(y)$ Probability distribution $H(y)$ Probability density

Fig. 2 Evaluation of diagrams according to different criteria

1 Weber, E.: Data Reduction by Data Processing. Siemens Review XXVIII (1961) pp. 137 to 140

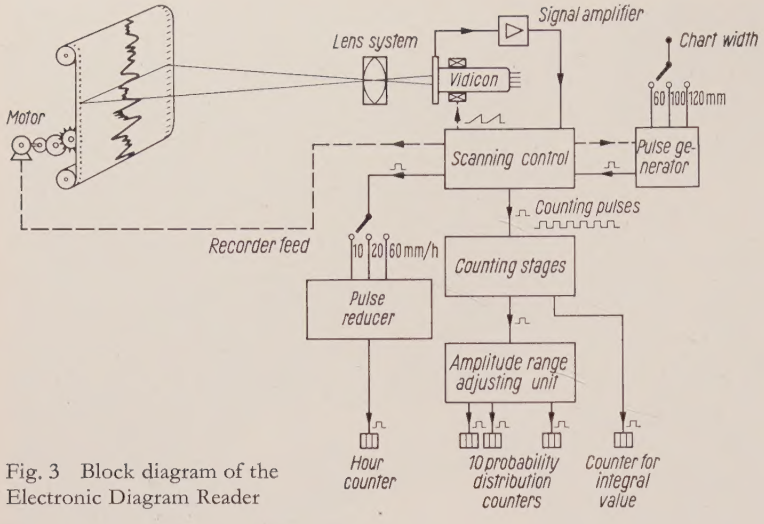


Fig. 3 Block diagram of the Electronic Diagram Reader

into a proportional period of time which is counted by means of pulses of a constant frequency. For determining the probability density, the pulses are counted according to the preselected amplitude ranges with the aid of ten electro-mechanical counters, and continually summed up for forming the integral. A further counter indicates the number of the hours on the scanned diagram.

The device comprises the following units:

Paper-feed unit with rewinding mechanism, illuminating equipment and projecting lens, Vidicon tube with signal amplifier, control unit, electronic counting stages, amplitude-range adjusting unit, electro-mechanical counters, controls, and power-supply unit.

Constructional Details

The total equipment is accommodated in two table sets. The scanning device proper contains the paper-feed unit, the projecting lens, the Vidicon tube with signal amplifier, the control unit, and the power-supply unit, while the analyzing device comprises the electronic counting stages, the amplitude-range adjusting unit, the electro-mechanical counters, and various operating elements.

The Scanning Device

As shown in Fig. 3, the chart is moved past the fixed scanning head. The rewinding mechanism contains three reels two of which are used as feed- and take-up reels, respectively, while the third, which is provided with sprockets engaging in the perforations of the chart, is driven by a synchronous motor, thus ensuring a constant paper feed.

Owing to the fact that the scanning system and the motor are both controlled by the a-c mains, the scanning is synchronous with the paper feed.

It will frequently be expedient to evaluate the curves in the same sequence in which they were plotted. After having been removed from the recorder, the chart roll must, therefore, be rewound in the diagram reader. For this purpose, the paper feed is reversed by means of a mechanical gear and its speed is usually trebled. Simultaneously, the analyzing device is switched off and the sprocket wheel is disengaged from the perforations. As soon as the chart is fully rewound, a limit switch will automatically stop the feed mechanism. If it is desired to evaluate a curve repeatedly, it is only required to rewind the chart roll each time without removing it from the feed unit.

The feed system with motor, rewinding gear, sprocket wheel, and the two removable chart reels can be swung out of the case for facilitating the replacement of records (Fig. 4). In its normal position, the feed unit is held by a locking device in correct alignment with the scanning head. The flanges of both the feed reel and the take-up reel, as well as that part of the sprocket roller which engages in the longitudinal slots of the perforation, can be adjusted by three catch positions to three different chart widths. The feed mechanism can be switched on or off at any point of its operation. When the equipment is set to "Evaluation", the analyzing device will be started or stopped together with the feed mechanism by a common control system.

The scanning head comprises the lens system with the Vidicon tube and the associated deflecting and focusing coils which are arranged, together with the signal amplifier and the saw-tooth generator, on a plate in the upper part of the case. The image projected onto the image plane of the Vidicon tube is converted into a potential distribution corresponding to the varying brightness of the projection. The electron beam, deflected along the amplitude axis of the diagram, scans the potential lines of the image at a constant speed, one at a time, and converts them into electric pulses which are amplified and separated from disturbances in the signal amplifier. The width of the scanned lines is about 0.5 mm (0.02 in.) referred to the paper surface. Hence, with 50 scanning lines per second and a feed of 20 mm/sec (0.8 in./sec), the chart advances 0.4 mm (0.016 in.) after each scanning sweep, the whole area of the diagram being continuously scanned in this way.

The whole scanning system is so adjusted that, at the very moment when the electron beam passes through the image of the zero line of the curve, a generator supplying pulses of constant frequency is switched on. The pulse generator is switched off as soon as the electron beam encounters a dark line. Thus the amplitude of the curve at the scanned point is converted into a proportional number of pulses. If the curve is blurred (due to running of the ink), or if it has a steep ascent, the time required by

the beam to traverse the curve will be comparatively long. Hence, if the generator would only respond to the transition from "white" to "black", a unilateral deviation from the actual amplitude value would result. This deviation is reduced, so as to become zero on an average, in the following way: When the beam passes over from "white" to "black", the generator is caused to produce pulses of half its normal frequency, and is switched off at the transition from "black" to "white", i.e., as soon as it leaves the trace of the curve.

The counting frequency is so chosen that exactly 100 pulses correspond to the amplitude value of 100%. This results in a maximum quantization error of ± 0.5%. When the chart roll is inserted, the pulse frequency is adjusted according to the width of the recording chart used.

The recording chart has an amplitude-and-time graduation. This graduation may not be black or of the color of the trace because the analyzing device cannot discriminate between graduation and curve, an automatic evaluation thus becoming impossible. This difficulty is overcome with a recording chart imprinted with colored co-ordinates. If the rays reflected by all colors except by that of the graduation are eliminated by a suitable filter, the contrast between the recording chart itself and the graduation disappears, and the latter becomes invisible to the Vidicon tube. A proven and particularly efficient combination is: blue ink, red graduation, and a red filter placed in front of the projecting lens.

The Analyzing Device

The analyzing device (Fig. 5) receives its counting and controlling pulses as well as its operating voltages from the scanning device via a 12-core cable. It processes the information supplied by the scanning device according to the characteristics shown in Fig. 2, viz. integral value, mean value, probability density and distribution, and number of hours on the scanned diagram.

Planimetering of the Curve and Formation of the Mean Value

The integral value of the scanned curve is obtained by totalizing all counting pulses. Given a paper length of 30 meters (98 ft) and a curve lying near full-scale values, this totalization would yield a sum of 7.5×10^6 pulses. Since the pulse frequency is as high as 20 kc, it is reduced by electronic counting stages. The number of pulses is determined and indicated by means of an electro-mechanical counter. The reducing stages are automatically adapted to the paper speed, so that the integral values are only dependent on the recording time and the amplitude characteristic. As a result, the integration constant is the same for all recording speeds.

The number of hours on the scanned diagram is likewise measured by a combination of electronic reducing stages and an electro-mechanical counter.

Since the paper speed will mostly be 10, 20, or 60 mm/hr (0.4, 0.8 or 2.4 in./hr.), the reduction can be so adjusted by means of a selector switch that, with each of these

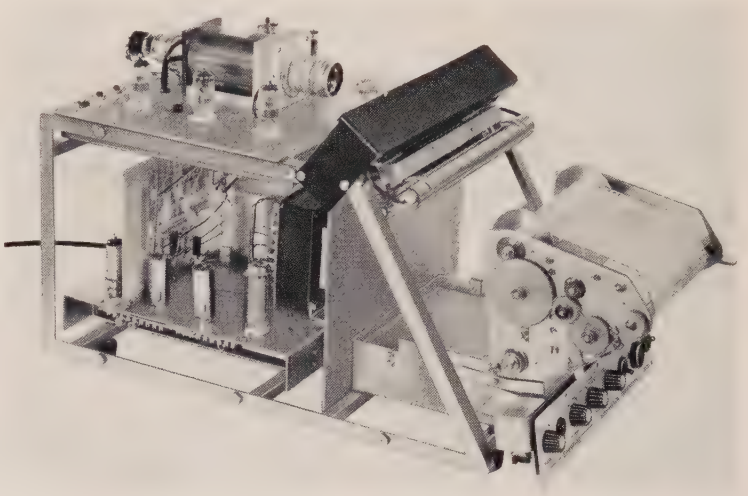


Fig. 4 Scanning device with paper-feed unit swung out, showing lens system, Vidicon tube, signal amplifier, control unit, and power-supply unit

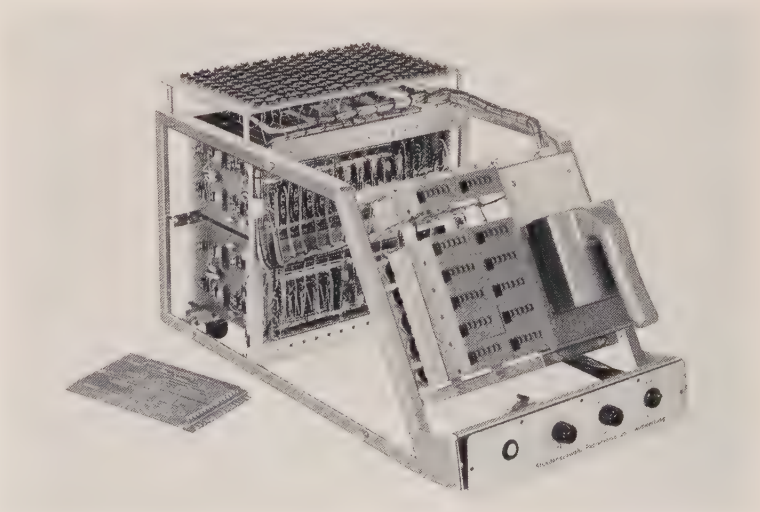


Fig. 5 Analyzing device with electronic counters, amplitude-range adjusting unit, electro-mechanical counters, and controls

paper speeds, the electro-mechanical counter is advanced by one step for each hour. By dividing the readings of the integral counter by that of the hour counter, the mean value of the scanned curve is obtained in per cent of the end value.

Statistical Evaluation

The statistical evaluation requires that the amplitudes of the diagram are grouped in ranges. For determining the probability density of the curve, the ranges to which its amplitude values belong are ascertained after each scanning operation. The counter assigned to this amplitude range will then receive a pulse. The total of all pulses indicated by the amplitude range counters at the end of the evaluation enables the probability density function to be plotted. For obtaining the probability distribution function, all counters assigned to the amplitude ranges lying below that of the curve must likewise be stepped on by one pulse. Either method may be applied at option.

For statistical purposes, the subdivision of the curve into ten amplitude ranges will mostly be sufficient. Hence ten counters are required which are actuated via transistorized reducing stages in the ratio of 2 to 1. The equipment for selecting the statistical amplitude range has the function of grouping the number of pulses, which may be 100 pulses per scanning sweep, into ten adjacent amplitude ranges. In contradistinction to the integrating counter which totalizes all counting pulses, the statistical counters indicate the pulses of the individual scanning operations starting from zero in each case. At the end of each scanning operation, the counter unit registers the amplitude value of the curve. The one hundred possible values are grouped in ten ranges by means of an amplitude-range adjusting unit with plug. By changing the wiring of the plug, any amplitude range, down to the smallest step of 1% of the amplitude peak value, can be obtained. As a rule, a subdivision into equidistant amplitude ranges will be preferred. It is, however, also possible to adjust, within given limits, any other function for the statistical evaluation, prewired plugs facilitating an exchange of the desired functions.

Evaluation of Interrupted Curves and Dotted-line Curves

It may happen that curves traced by continuous-line recorders show short interruptions, or that, in the case of sudden variations of the measured variable, the trace becomes so blurred that it cannot be picked up by the scanning device. Frequent interruptions of this kind might cause errors in the result of evaluation. For preventing this, the Diagram Reader was supplemented by a built-in accessory device. The amplitude range counters are controlled by a memory circuit which receives the amplitude range value at the end of each scanning operation and transmits it to the amplitude range counters at the beginning of the next scanning operation.

Transmission and erasing of the memory circuit are blocked if the curve is interrupted, since the stop pulse of the scanning device is absent and more than 99 pulses are counted. As soon as the blocking device operates, the last correctly scanned value is transmitted to the counters, i.e. the curve is continued by straight lines running parallel to the time axis. As a result, the error will mostly remain negligibly small. The same applies to the evaluation of curves traced by dotted-line recorders.

Evaluation of Diagram Portions

Besides the continuous evaluation method, it is desirable to have the possibility of evaluating, at 24-hour intervals, only predetermined portions of the record covering certain hours of the day, for examining recurrent phenomena. Thus, by repeatedly evaluating the curves, a survey of the statistical magnitudes and the integral value of certain time intervals can be obtained. A 24-pole switch enables the interesting chart portions to be selected. These portions are scanned in a 24-hour cycle. During the remaining time, the feed mechanism keeps running at a continuous speed without an evaluation taking place. At the commencement of the scanning operation, the starting point of the periodical scanning is adjusted on a mark of the paper-feed unit.

Technical Data

Scanning Device

Recording width
60, 100, and 120 mm (2.4, 3.9, and 4.7 in.)
(marginal perforation)

Maximum paper length 30 m (98 ft.)

Minimum thickness of the trace 0.25 mm (0.01 in.)
(blue or purple ink)

Paper feed
20 mm/sec (2.4 in./sec) for scanning, about 60 mm/sec (3.9 in./sec) for rewinding

Duration of an evaluation
25 min. for a 30-m (98-ft.) record

Power supply
220 v, 50 cps, 140 w

Dimensions
300 mm × 330 mm × 520 mm (12 in. × 13 in. × 20.5 in.)

Weight
about 24 kg (53 lbs.)

Analyzing Device

Evaluation
Planimetering of the area below the curve (integral value), counting of hours on the scanned diagram

Probability distribution or probability density
Continuous evaluation or periodical evaluation in a 24-hour cycle, predetermined diagram portions adjustable

Amplitude ranges
Adjustable by means of several plugs, 10 ranges max.

Indication of results
Electro-mechanical six-figure set-back counters

Extension facilities
Connection to a memory circuit automatically storing and processing the results

Electronic subassemblies
Plug-in type transistorized units with printed circuits

Dimensions
300 mm × 330 mm × 520 mm (12 in. × 13 in. × 20,5 in.)

Weight about 15 kg (33 lb.)

A New Electropneumatic Potentiometer Controller

By Hermann Burkard and Wilhelm Neuse

The new electropneumatic potentiometer controller, which replaces the former small- and large-type electropneumatic controllers, is the product of a development utilizing the experience of almost ten years in the design, manufacture and operation of electropneumatic controllers. In addition to the applications of the former controllers, the various embodiments of the new controller permit the solution of complex control problems occurring in continuous or batch processes.

Scope of Application

Large industrial processing plants are nowadays mostly equipped with standardized electric and pneumatic control systems. A typical representative of such automatic control systems is the Teleperm*-Telepneu* system which renders purely electric, purely pneumatic and any combined electropneumatic control actions possible[1].

Standardized control systems derive particular advantages from the use of transducers converting all measured variables into standard, load-independent current or pressure signals which readily lend themselves to being transmitted over comparatively long distances.

As a result, the control room can be equipped with devices of uniform design for all control problems. The actual and desired values of the controlled variables, as well as all command, ratio and manipulated variables, can be plotted with the aid of standardized recorders. Owing to the uniformity of the signals, the use of data-processing devices and computers has been considerably facilitated.

The choice of the instrumentation of small industrial processing plants, however, is frequently governed by quite different considerations. For economical reasons, the costs for the measuring and controlling devices should not exceed a certain portion of the total cost of the plant. This implies that the control equipment, while satisfying the same requirements as to accuracy and reliability, should be less expensive than that of larger plants. In small processing plants it is neither necessary to bridge great distances, nor is it prerequisite that the actual value and other information concerning the controlled variable should be recorded. An indication of the deviation will mostly be sufficient. Hence the idea suggests itself to dispense altogether with the use of transducers, and to connect the input of the controller direct with the sensing element (thermocouple, resistance thermometer, measuring instrument with simple electric pickup, etc.).

The new electropneumatic controller built-up by a measuring unit and a control unit meets all these requirements. The measuring unit (Fig. 1) is designed

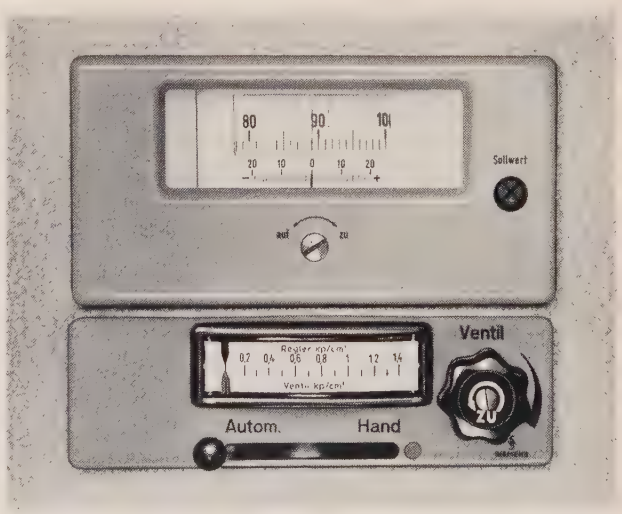


Fig. 1 Measuring unit of the controller and manual/automatic selector switch mounted in a panel

* Trade-mark

1 Matuschka, H. and Sartorius, H.: The Combined Teleperm-Telepneu Automatic Control System. Siemens Review XXV (1958) pp. 107 to 113

for panel flush-mounting. Its front-frame dimensions are 144 mm × 72 mm (5.7 × 2.8 in.). The control unit can be accommodated behind the switchboard or at any other convenient place within the plant. The considerable amplification effect of the controller enables the measuring circuit to be so arranged that all usual kinds of sensing elements can be directly connected (i.e. without the use of transducers or amplifiers). All units of the controller are composed of unitized structural elements. Their possible combinations are listed on page 149.

Mode of Operation

The measuring unit of the controller can be equipped with different measuring circuits according to the sensing elements used, e.g. resistance thermometers, thermocouples, wire strain gauges, pH-meters, humidity meters, flow meters, etc.

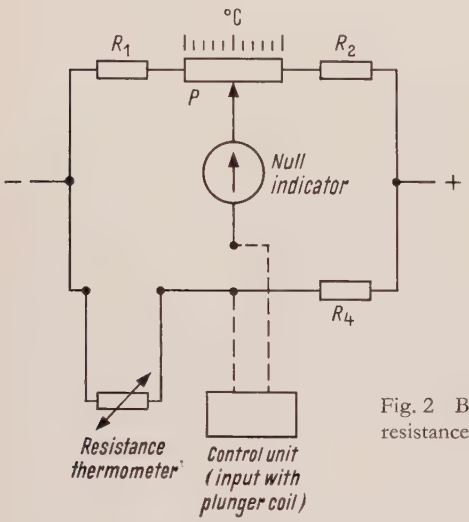


Fig. 2 Bridge circuit for resistance thermometers

Bridge circuits are mostly used for comparing the actual value with the desired value. Fig. 2 shows, by way of example, a bridge circuit for resistance thermometers in two-wire connection. The potentiometer is set for the desired temperature value. If the temperature measured by means of the resistance thermometer deviates from the desired value, the bridge circuit is unbalanced. As a result, a current corresponding as to its intensity and direction to the deviation is generated in the diagonal arm of the bridge, passes through a null indicator (deviation) and energizes a plunger coil at the input side of the control unit (Fig. 3).

The plunger coil, arranged in the air gap of a powerful, pot-shaped magnet, moves to one side or the other according to the direction of the current traversing it. The movement of the plunger coil is taken up by a taut-strip-suspended one-arm lever and a helical spring fixed to the latter at its fulcrum end. The other end of the lever carries the flapper of a nozzle system consisting of a discharge nozzle and an intake nozzle. Since the air current from the discharge nozzle is being kept constant by an overflow valve, the air current received by the intake nozzle is dependent on the position of the flapper between both nozzles.

When, owing to the energization of the plunger coil, the flapper is displaced, the pressure in the intake nozzle will change. The extent of this change is intensified about 500-fold by a control relay (diaphragm-nozzle system). The working scope at the output of the control relay covers 0.2 to 1 kg/sq. cm (2.9 to 14.7 psi). The dependence of the output pressure on the intensity of the current flowing in the plunger coil is almost linear.

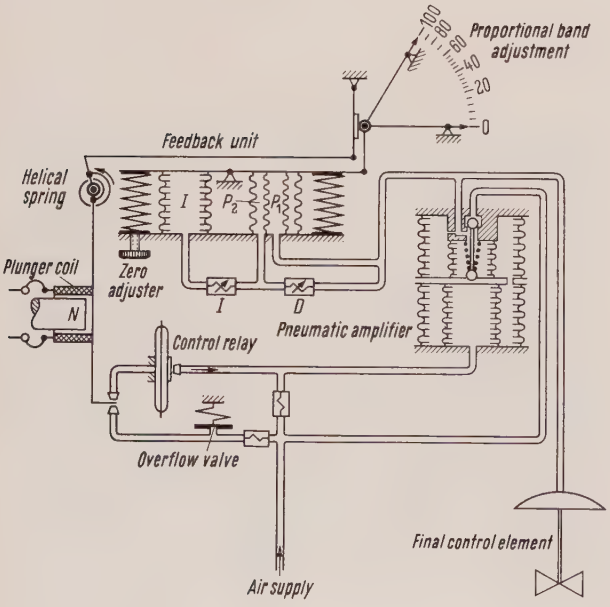
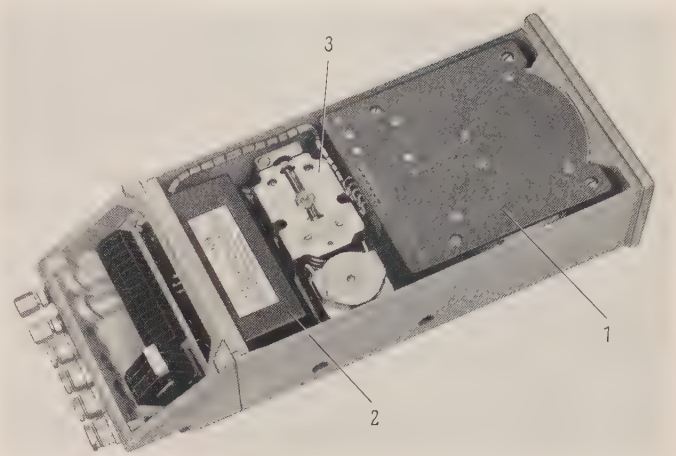


Fig. 3 Functional circuit diagram of the proportional-plus-reset-plus-rate-action control unit with pneumatic amplifier

The output of the control relay will mostly suffice for such control problems which are characterized by slowly changing actual values. If, however, a greater air output is required, the equipment must be supplemented by a pneumatic amplifier. In this case, the control relay actuates the pneumatic amplifier which, in turn, actuates both the final control element and the feedback unit. The pneumatic amplifier with non-bleeding valve, which is of the negative-feedback type, operates on the force-balance principle and features proportional-plus-reset action. The working scope at its output covers also 0.2 to 1 kg p. sq.cm (2.9 to 14.7 psi). In comparison to the controller type where the control relay is used as only amplification means, the pneumatic-amplifier type features a quicker action, an input for full operating range of one tenth, and a ten times higher output.

The feedback unit consists of a force balance held in position by two springs, one at either end (Fig. 3). It contains a double bellows (P_1, P_2) for the negative feedback, and a further bellows (I) for the positive feedback.

The negative-feedback pressure is applied without delay to the inner bellows P_1, while, for producing the rate action, it is applied with delay to the outer bellows P_2 through an adjustable restriction D. For producing the reset time, the feedback pressure is once more applied with delay to the positive-feedback bellows I through the adjustable restriction I. By means of a lever system, whose ratio can be varied for adjusting the proportional band, the movement of the force balance is transmitted to the helical spring at the fulcrum end of the lever attached to the plunger coil. If the feedback unit is not balanced, the spring will exert a torsional force, which is opposed, and almost equal, to the torque produced by the plunger coil.



1 Manual set-point adjuster 2 Power pack 3 Pneumatic set-point adjuster

Fig. 4 Measuring unit, cover removed

Design of the Measuring Unit

The measuring unit contains the set-point adjuster, the null galvanometer for indicating the deviation, the measuring circuit, and the power pack (Figs. 1 and 4). The measuring circuit is accommodated in an extractible, drawer-type plastic casing (Fig. 5). Thus the adjustments required for putting the controller into operation can be made from the front. Moreover, the measuring circuit can be exchanged on site.

As mentioned above, the measuring unit (Fig. 4) can be furnished with measuring circuits adapted to all usual electric sensing elements. For resistance thermometers, not only the above-described two-wire connection, but also a three-wire connection is applicable, and preferable if the leads are long and subject to considerable temperature fluctuations.

For bridge circuits (e.g. with resistance thermometers), which are unsusceptible, to a high degree, to changes of the bridge-supply voltage, a simple power pack without stabilizer is used. For effecting bridge measurements of small voltages, e.g. of voltages derived from thermocouples, it is required that the bridge voltage should be constant. In this case, a power pack containing a two-stage stabilizer equipped with Zener diodes will serve the purpose. Both types of power packs are filled up with synthetic resin and comply with the regulations against explosion hazard VDE 0171/957 (Association of German Electrical Engineers).

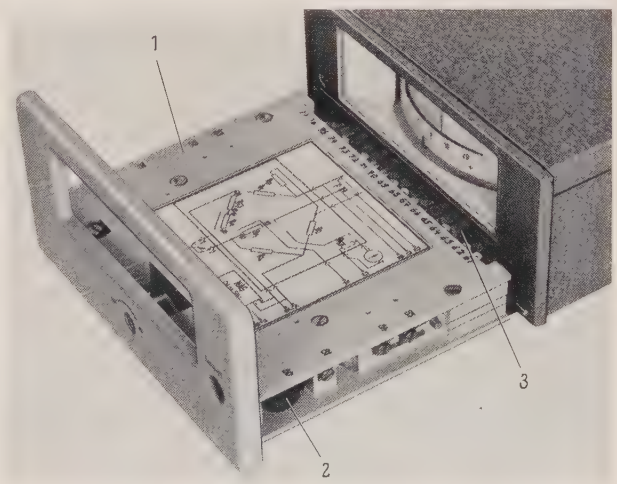
If the set point is not to be adjusted manually (e.g. in the case of cascade control), a pneumatic set-point adjuster with turbine-wheel drive can be incorporated in the measuring unit.

Design of the Control Unit

The proportional-plus-reset-plus-rate-action control unit with pneumatic amplifier has already been described in the paragraph headed "Mode of Operation".

This unit can be easily transformed into a proportional-plus-reset control unit by removing the rate-action restriction (D) and short-circuiting the line, so that the feedback pressure arrives undelayed at the outer negative-feedback bellows P_2. For modifying the unit so as to function as a proportional position-action controller, the reset restriction (I) is likewise to be eliminated and the feed line closed by means of a stop plate. The positive-feedback bellows I remains inoperative and open to the ambient atmosphere. All embodiments of the control unit provide zero adjustment within the limits of 0.2 to 1 kg/sq.cm (2.9 and 14.7 psi).

If sensing elements of a power output of less than $2 \cdot 10^{-6}$ watt (e.g. Pt/Pt Rh thermocouples) are connected to the input of the measuring unit, the latter must be provided with a plunger coil of higher sensitivity, whose taut-strip



1 Plastic case with incorporated measuring circuit 2 Adjusting coil 3 Terminals

Fig. 5 Measuring unit, drawer pulled out

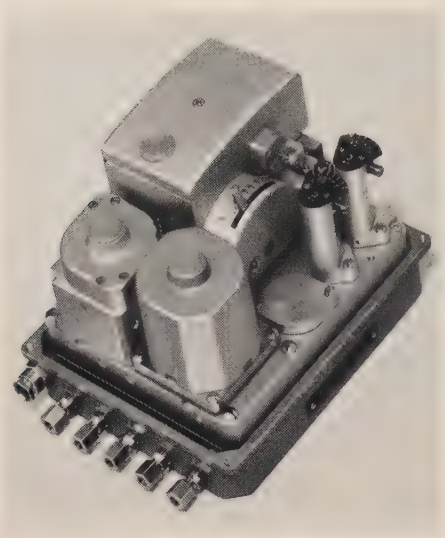


Fig. 6 Control unit of the proportional-plus-reset-plus-rate-action controller type with pneumatic amplifier

suspension has a smaller torque than that of the standard type. In the case of sensing elements delivering an output of more than $2 \cdot 10^{-5}$ watt for the total measuring range, the working range of the controller is so small that the pneumatic amplifier may be dispensed with, provided that the required control-air output is not too great.

The connection of a TELEPNEU manual/automatic selector switch (see Fig. 1), enabling the final control element to be actuated either manually or through the controller, requires that a short-circuiting relay should be incorporated in the control unit if the distance between the manual/automatic selector switch and the control unit exceeds 5 meters (16 ft. 5 in.).

For facilitating the starting of controlled systems having a comparatively long dead time, e.g. of autoclave processes, the incorporation of a proportional/integral-action change-over relay is provided. The purpose of this relay is to prevent the controlled variable from overshooting by effecting that the proportional-plus-rate action of the feedback unit is not changed into a proportional-plus-

Fig. 7 Mounting plate (opened)

	Resistance thermometers	Sensors with current or voltage output
Mains voltage	125 or 220 v (+15 or −20 %)	
Mains frequency	50 or 60 cps	
Power consumption	about 1 va	about 5 va
Resistance of the desired-value potentiometer	50 ohms ± 2 %	
Resistance of the null indicator	450 ohms ± 5 %	
Sensitivity of the null indicator	0.5 μa/div.	
Minimum span of the measuring range	50°C for 100-ohm resistance thermometers	6 mv or 0.13 ma
Accuracy	± 0.3 % of the measuring-range span	± 0.5 % of the measuring-range span

Table 1 Technical data of the measuring unit

	Without amplifier	With pneumatic amplifier	With pneumatic amplifier and sensitive plunger coil
Response sensitivity	<0.025 μa	<0.025 μa	< 0.01 μa
Response power	$<10^{-13}$ w	$<10^{-13}$ w	$<10^{-14}$ w
Minimum power of the sensing element for full measuring range	$2 \cdot 10^{-5}$ w	$2 \cdot 10^{-6}$ w	$2 \cdot 10^{-7}$ w
Input for full operating range			
for proportional band 0	± 6 μa	± 0.5 μa	± 0.25 μa
for proportional band 100	± 6 μa	± 1 μa	± 0.25 μa
Adjustable proportional band	± 6 to ± 320 μa	± 1 to ± 320 μa	± 0.4 to ± 50 μa
Dependence of the desired value on the proportional band	max. 1 μa	max. 1 μa	max. 0.2 μa
Dependence of zero point on air-supply pressure	0.3 μa per 0.1 kg/cm² (1.42 psi)	0.15 μa per 0.1 kg/cm² (1.42 psi)	0.08 μa per 0.1 kg/cm² (1.42 psi)
Maximum air consumption	6 liters per min* (1.6 gal per min)	7 liters per min* (1.85 gal per min)	7 liters per min* (1.85 gal per min)
Maximum air output	5 liters per min* (1.32 gal per min)	50 liters per min* (13.2 gal per min)	50 liters per min* (13.2 gal per min)
Range of adjustment of feedback unit	Rate time 0.1 to 25 min Reset time 0.1 to 50 min		

* under standard conditions

Table 2 Technical data of the control unit

reset-plus-rate action before the controller has reached the adjusted proportional band.

The following eight embodiments are available:

1. Proportional position-action controller
2. Proportional-plus-reset-action controller
3. Proportional-plus-reset-action controller with proportional/integral-action change-over relay
4. Proportional position-action controller with pneumatic amplifier
5. Proportional-plus-reset-action controller with pneumatic amplifier
6. Proportional-plus-reset-action controller with pneumatic amplifier and proportional/integral-action change-over relay
7. Proportional-plus-reset-plus-rate-action controller with pneumatic amplifier
8. Proportional-plus-reset-plus-rate-action controller with pneumatic amplifier and proportional/integral-action change-over relay.

Embodiments 5 and 7 (Fig. 6) can be furnished with short-circuiting relays.

The individual subassemblies are so designed that embodiment No. 1 can be easily transformed on site into any one of the other versions Nos. 2 to 8. This facility results in a great adaptability of the controller to all control and installation problems that may present themselves.

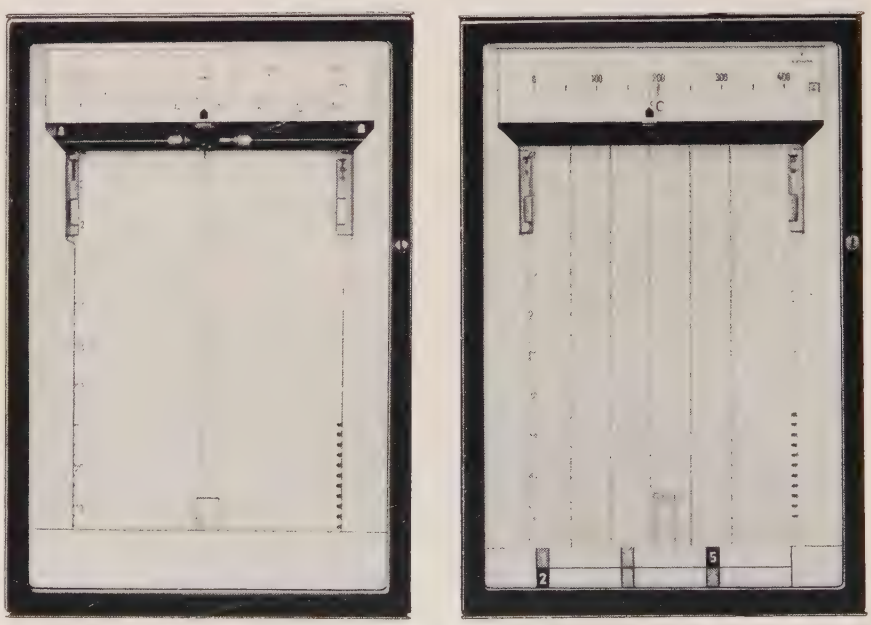
Die-cast channels are provided in the mounting plate for all pneumatic connections required (Fig. 7).

The essential technical data relating to the control unit are compiled in Table 2.

The New Potentiometric Recorder KOMPENSOGRAPH 192×288

By Helmut Kaulfersch and Franz Schubert

Some types of recording instruments nowadays required for the purposes of research and production must satisfy exacting demands, such as wide recording range, particularly high accuracy, short response time, extraordinary reliability, and simple maintenance. These demands can only be met by recorders operating on the potentiometric method which provides that a potentiometer is controlled through a servomechanism. As a rule, this mechanism comprises an electronic amplifier and a geared servomotor. The adjustable part of the potentiometer is rigidly coupled with the indicating and recording unit of the instrument. If the output of the amplifier is sufficiently high, a powerful servomotor will rapidly and safely actuate even indicating and recording devices of sturdy design suitable for industrial applications and requiring a comparatively high power. As a result, great accuracy, short response time, and a substantial improvement of measurement are obtained, all the more so as recorders of this type are insensitive to position, and neither considerable changes in the friction of the moving parts nor sensible irregularities in the manipulation and maintenance will affect the indication. Moreover, besides driving the measuring potentiometer, the strong positioning forces available are capable of actuating quite a number of accessory devices such as additional



Continuous-line recorder — Six-color dotted-line recorder

Fig. 1 KOMPENSOGRAPH 192 × 288 (standardized size in mm according to German Standard Specification DIN 43831)

potentiometers, limit-value indicators, and analog-digital converters.

These accessories are gaining more and more importance for data processing and telemetering purposes.

For the solution of certain problems, potentiometric recorders have proved such a success that their more general application is now contemplated. Consequently, the demand for smaller dimensions was raised.

The new potentiometric recorder Kompensograph* 192×288 (Fig. 1) meets all above-mentioned requirements to perfection. While this instrument retains the well-proven potentiometric method, its essential electronic and mechanical members embody the latest technical achievements.

The Measuring Circuit and its Subassemblies

Fig. 2 shows the principle of operation. The auxiliary current i_H supplied by a constant current source passes through the measuring potentiometer R connected into the measuring bridge. The reference voltage E_V tapped off from the measuring potentiometer is connected in opposition to the voltage to be measured E_X. The resulting differential voltage E_D is applied to the input of an inverter amplifier whose output is connected to the control winding of a two-phase induction motor which controls the slider of the measuring potentiometer in such a way that the differential voltage E_D is reduced to zero. The displacement of the slider, as well as that of the recording device, which is rigidly coupled with the slider, is proportional to the input voltage. Thus, the approved basic features of the Kompensograph 398×480 were retained, while the individual electronic units were redesigned. The smallest measuring ranges covered by the new recorder are shown in Table 1. All variables that can be transformed into electric currents or voltages, as well as resistances measured in three- or four-wire connection, can be recorded.

The measuring potentiometer calibrated for both end values is mounted as a separate unit of the bridge circuit. The resistance coils determining the measuring ranges are accommodated in exchangeable boxes (Fig. 3). Complete sets of boxes are available. Therefore, the ranges can be changed without affecting the calibration, and the user may keep an adequate assortment of boxes in readiness to meet any contingency.

All components belonging to both the measuring circuit and the auxiliary circuit (except those of the potentiometer and amplifier) are comprised in the control unit (see Fig. 3).

For enabling the instrument to be rapidly adapted to variables of different magnitude without its recording operation having to be interrupted (as it may be required for measurements in the laboratory or test room), a manual selector switch for two or three measuring ranges has been provided.

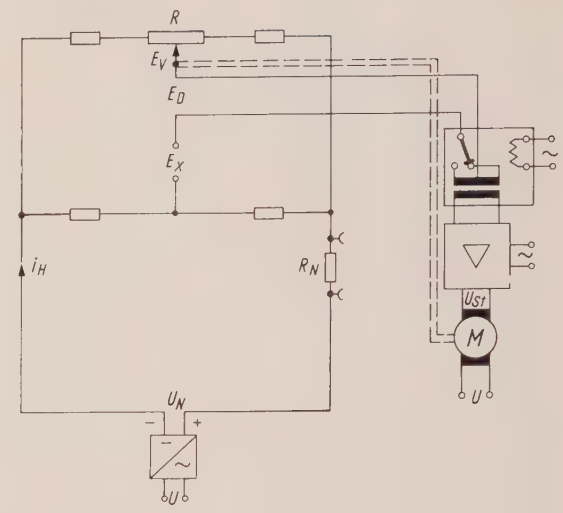
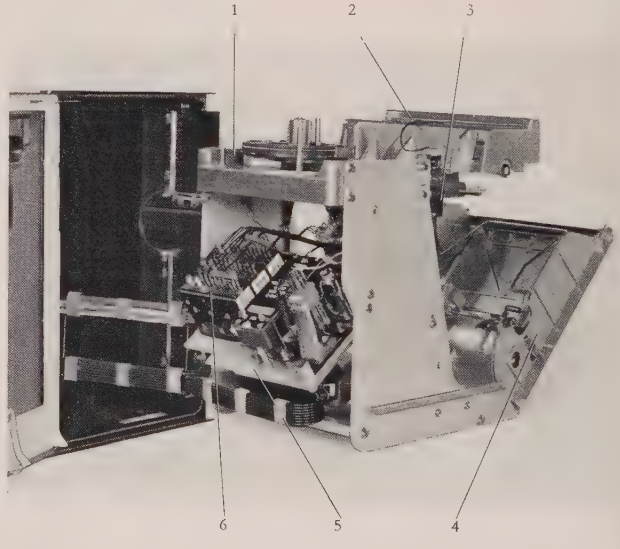


Fig. 2 Basic circuit diagram of the Kompensograph 192 × 288

Two basic types of balancing amplifiers are available, viz. an electronic amplifier and a magnetic amplifier (Fig. 4). An inverted rectifier converting the direct voltage into alternating voltage of proper phase relation according to the d-c polarity is incorporated at the input side of the electronic amplifier. The amplified differential voltage energizes the control winding of the motor. An unbalance of the measuring circuit of only about 2% will already cause the full control voltage to be applied to the motor which runs with constant speed.



1 Servomotor unit
2 Recording unit
3 Ink bottle
4 Paper-feed unit
5 Control unit
6 Measuring-range boxes

Fig. 3 The measuring unit, the control unit, and the paper-feed unit of the Kompensograph 192 × 288 are accessible during operation

* Trade-mark

Lowest measuring ranges	Standard design: 5 mv Special design: 1 mv
Built-in measuring ranges	3 max.
Limits of error	±0.5%
Error of balancing	smaller than ±0.2%
Response time	0.4 to 48 sec
Interval between dots	2 to 48 sec
Recording width	120 mm ($4^3/_4$ in.)
Visible length of graph	190 mm (7.5 in.), 9.5 hr at 20 mm/hr
Electronic amplifier	1 mv and upward (input resistance with unbalanced bridge 2 kilohms, shortest response time 0.4 sec)
Magnetic amplifier for indirect current measurement	2.5 ma and upward, shortest response time 4 sec
Supply voltage and consumption	220 v, 50 to 60 cps, 40 va
Rated temperature	20 °C (68 °F)
Operating temperature	0 °C to 45 °C (32 to 113 °F)
Accessories	2 additional potentiometers 4 limit contacts (2 max. and 2 min. values) 2 end-position contacts

Table 1 Main characteristics of the Kompensograph 192 × 288

The amplitude of overswing occurring when the variable to be measured is suddenly switched into circuit, is readily adjustable. The effect of the damping circuit (synchro-generator equivalent circuit fed by a tap of the servomotor control winding), which has stood the test in the former Kompensograph type 398×480, could be further improved. As a result, the minimum time required by the pen to travel across the paper was reduced down to 0.4 sec, such high recording speeds being necessary, e.g., for the measuring methods applied in reactor engineering and gas chromatography.

The magnetic amplifier is designed for increasing the power level of the load-independent direct currents used in the operation of the Teleperm* system. The measuring range of the instruments intended to be used in Teleperm equipments is determined by the voltage drop produced by the load-independent current of the transducer across an incorporated resistor.

The shortest balancing time for full-scale deflection of a recorder equipped with a magnetic amplifier is 4 sec. This recording speed, however, is fully sufficient for the purposes of industrial processing because only slowly changing variables are to be dealt with. Owing to its low cut-off frequency (approx. 4 cps), the magnetic amplifier is quite unsusceptible to stray alternating voltages. Since it measures the mean d-c value, the curve shape of the current to be measured is of no significance. Although

* Trade-mark

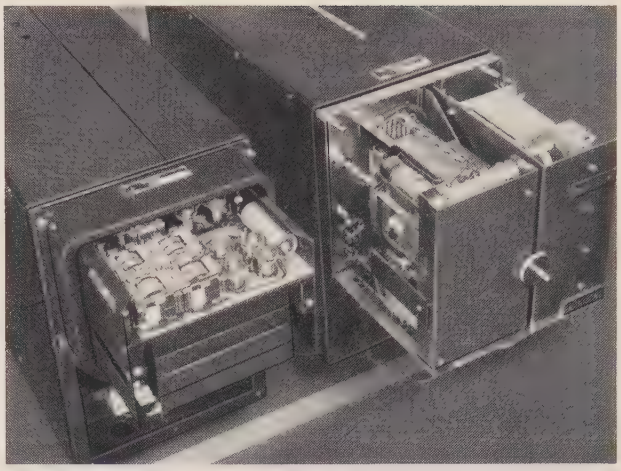


Fig. 4 The amplifier of the Kompensograph 192 × 288, which is accessible after the removal of a protective cover, is attached to the rear wall of the instrument; magnetic amplifier (left) and electronic amplifier (right)

the Kompensograph with incorporated magnetic amplifier for indirect current measurement (smallest measuring range 2.5 ma) is of simple construction, it satisfies to a high degree any requirements as to positioning power, accuracy, and consumption.

The constant-current source, operating with Zener diodes (Fig. 5), utilizes the recent progress in semiconductor engineering. Endurance tests have proved that, without being readjusted, the auxiliary current will not vary by more than ±0.02% of the originally adjusted value within a period of eight months. The influences of temperature, frequency, harmonics, and mains-voltage fluctuations upon the two-stage constant-current source amount to less than ±0.1%. Because of these negligible influences and the high constancy in time (small drift of the auxiliary current) an arrangement with an incorporated standard primary cell for balancing the auxiliary current could be dispensed with. Consequently, also any additional error, which would likely be caused by

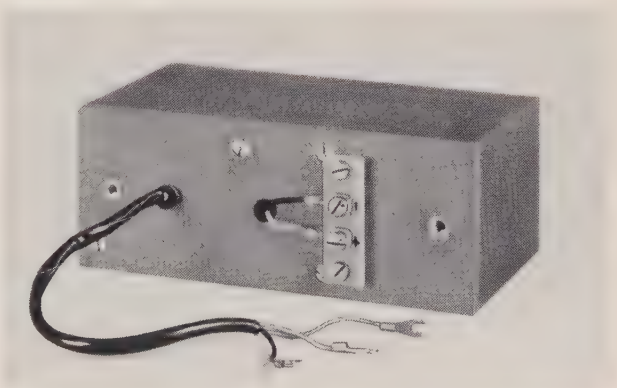
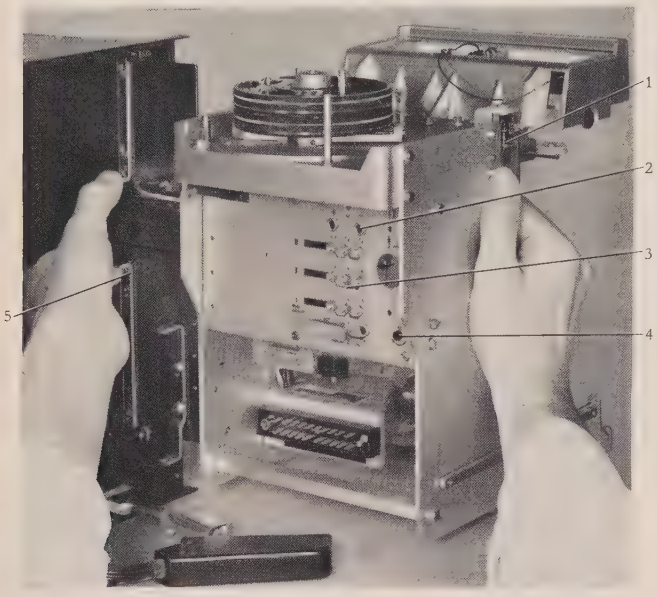


Fig. 5 Sealed stabilizer unit

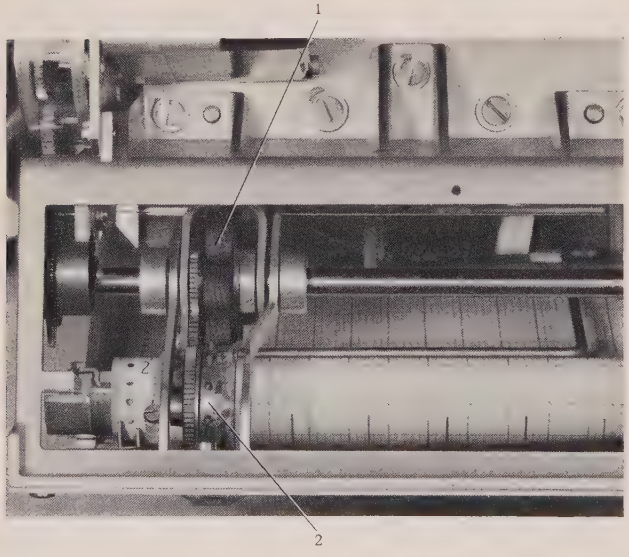
the influence of temperature on the standard cell, is eliminated.

In order to give the user, nevertheless, the possibility to keep the auxiliary current under control, the standard type of instrument is provided with test jacks (see Fig. 6). These jacks are connected to a standard resistance R_N (see Fig. 2) across which a voltage drop of 1.0187 v (voltage of the standard cell) occurs.



1 Ink bottle
2 Test jacks
3 Test panel
4 Adjustable resistor
5 Mechanical locking device

Fig. 6 After withdrawing the connecting plug and unlatching the mechanical locking device, the complete measuring unit of the Kompensograph 192 × 288 can be removed from the case



1 Inking pad
2 Printing head

Fig. 7 Printing device of the six-color dotted-line recorder

Design

The instrument is designed on the principle of unit construction. Its individual subassemblies are self-contained, independently functioning, electrically, electronically or mechanically operating units, capable of being individually tested. Particular importance was attached to simple, easy handling and to the possibility to readily exchange complete units if this should prove necessary for maintenance purposes or for adapting the instrument for other applications (see Fig. 3).

Attendance and Maintenance

The external appearance of the instrument (see Fig. 1) is in keeping with the matter-of-fact architectural design of modern control rooms. After opening the door of the case, the record can be removed or the paper feed changed in the ratio of 1:3:6 without any interruption of the recording operation taking place. Moreover, a new paper roll can be inserted without the paper-feed unit having to be removed from the case. For adapting the degree of either amplification or damping to the measuring problem in hand, for testing the auxiliary current, or for maintenance purposes (cleaning of the potentiometer), the complete measuring unit can be swung out of the case (see Fig. 3), while the instrument continues operating. Then the test panel for checking the measuring circuit is also accessible. The test can be carried out without the instrument leads having to be disconnected or their connections changed.

The servomotor unit (see Fig. 3) is designed in such a way that a pressure casting provides the seats for the measuring potentiometer and the servomotor with gearing and rope guide for driving the recording and indicating device. The seat for the measuring potentiometer is so dimensioned that two additional potentiometers can be installed. For doing so, it is not required to loosen the play-free fastening of the slider arm. A friction clutch is interposed between the slider and its rope pulley on the one hand and the transmission gear on the other. As a result, no undue torques will be produced by the recorder carriage when deadlocking in one of its end positions due to over-modulation of the amplifier.

By simply interchanging some wheels in the gearing between the servomotor and the measuring potentiometer, the time required for full-scale deflection can be changed within the limits of 0.4 and 48 seconds.

The additional potentiometers can be furnished with resistance values up to 10 kilohms. Their graduation differs by less than ±0.1% from a strictly linear graduation. This fact enables the measured values to be transmitted over long-distance lines, and digital translators, counters, integrators, indicators, and other measuring instruments to be connected as desired. Irrespective

of the number of additional potentiometers, and without impairing the accuracy of the instrument, up to four limit contacts (with associated microswitches) can be attached to the recording unit for enabling any measured values to be signalled.

Recording and Printing Devices

The ink is fed from a fixed reservoir through a flexible tube to the recording pen (Figs. 3 and 6). The recorder will operate for several weeks without any attendance being required, provided that ink and paper are of good quality. Even if the instrument has been out of service for some days, the record will be traced immediately after starting, provided that the pen was not lifted off the paper during the inoperative period.

The standard recording pen can be replaced by a ball-point stylo. This, however, is only recommendable in exceptional cases, e.g. if the variable to be measured is liable to undergo rapid, oscillatory changes, and if, in addition, the paper feed is slow.

The printing device (Fig. 7) is designed for up to six measuring points. The dots and the figures representing the measuring points are printed in the six colors assigned to the latter. As in the case of the Kompensograph 398×480, the figures appear in intermittent and staggered sequence. The printing head is small and light so that its dead weight is of no consequence.

The printing device is easily accessible from all sides. Therefore, cleaning of the types and exchanging of the inking pads present no difficulty.

Vacuum X-ray Fluorescence Analysis for Elements with Atomic Numbers between 12 and 22

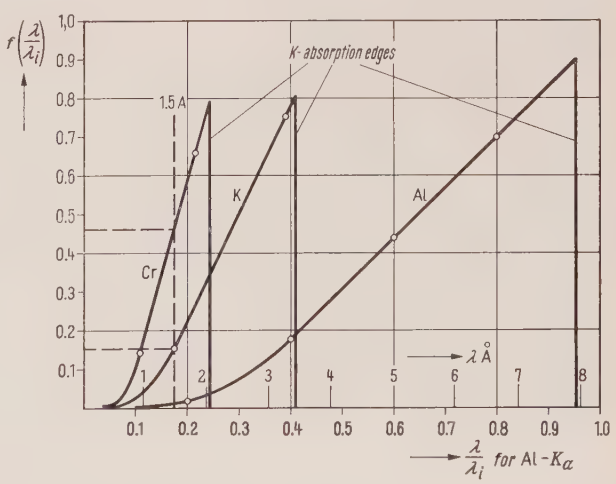
By Kurt Tögel

In recent years, the technique of x-ray fluorescence analysis has found a wide range of applications, due to the simplicity of the analyses for powder as well as liquid samples and to the high precision and reproducibility of the analytical results. For routine analyses, x-ray fluorescence methods are often superior to other techniques with respect to reproducibility and time requirements. For substances of essentially unknown composition, semi-quantitative analyses can be completed in a minimum of time. The physical fundamentals and the techniques of this method have been described previously [1]. While a simple spectrometer arrangement will be satisfactory for all elements with atomic numbers "Z" between 22 and 92, the analysis for elements with atomic numbers between 22 and 12 becomes somewhat more difficult due to rapidly decreasing intensity of the characteristic x-ray lines (λ = 2.5 to 10 Å) and due to their rapidly increasing absorption. However, the development of vacuum spectrometers, of special-purpose detectors, of efficient x-ray equipment, and, in particular, of x-ray tubes suitable for high-load operation have resulted in such an improvement of the analytical techniques for these elements (some of which are of considerable commercial importance) that high analytical precision can now be obtained in relatively short time.

Discussion of the Critical Physical Quantities

With decreasing atomic number, the maximum intensity of the characteristic x-ray spectra of the elements decreases rapidly; as compared with elements with higher atomic numbers, this results in a decrease of the analytical precision or in a shift of the lowest detectable concentration to a higher value. The reduced intensity results primarily from the very low fluorescence yields and from the low excitation probability for the long-wave spectra of these elements.

The probability of excitation, f, of a characteristic x-ray line, λ_i, is a function of the exciting wavelength, λ. From



λ Wavelength of the exciting radiation λ_i Wavelength of the Al-K_α line = 8.3 Å

Fig. 1 Probability of excitation, f, for the Al-K_α x-ray line as a function of (λ/λ_i), and for the K-K_α and Cr-K_α lines as a function of λ

the laws of x-ray absorption, there is obtained [2]:

$$f(\lambda/\lambda_i) = \frac{(\lambda/\lambda_i)^4}{(\lambda/\lambda_i)^3 + 1/S_q}$$

S_q is the magnitude of the absorption discontinuity of the pertaining absorption edge. This equation is valid only for $\lambda < \lambda_k < \lambda_i$ where λ_k is the wavelength of the absorption edge. Fig. 1 shows the change of f as a function of (λ/λ_i) for the Al-K_α line ($\lambda_i = 8.3$ Å; $\lambda_k = 7.9$ Å; $S_q = 12.6$).

For a comparison, the exciting wavelength λ (in Å) is also shown as the second abscissa. The function $f(\lambda)$ is also shown for the Cr-K_α and K-K_α lines. To obtain optimum excitation for the Al-K_α line, x-rays with wavelengths up to 7.9 Å should be used. The x-ray tubes commonly used for x-ray fluorescence analyses are already equipped with beryllium windows, so as to operate with a minimum absorption for the x-rays with longer wavelengths. However, requirements for vacuum, mechanical and temperature stability make it necessary to use windows of a thickness which, for example, reduces the intensity of x-rays with a wavelength of 3.5 Å to 20% of the initial value and which absorbs x-rays of still larger wavelengths to such an extent that they cannot contribute significantly to excitation. At a wavelength of 1.5 Å (which is emitted at very high intensity from an x-ray tube with a tungsten anode), the f-values, and therefore the intensities, of the K_α lines of Cr, K, and Al are at a ratio of 46 : 15 : 1. Consequently, the limiting factor with respect to the excitation of the spectra is the x-ray tube.

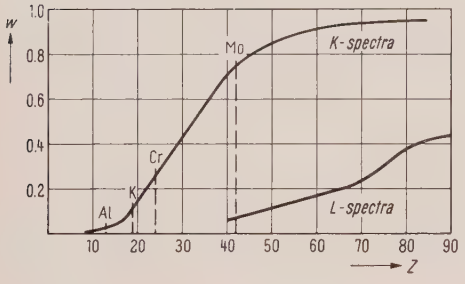


Fig. 2 The fluorescence yield, w, for the K and L spectra as a function of the atomic number, Z, of the chemical elements

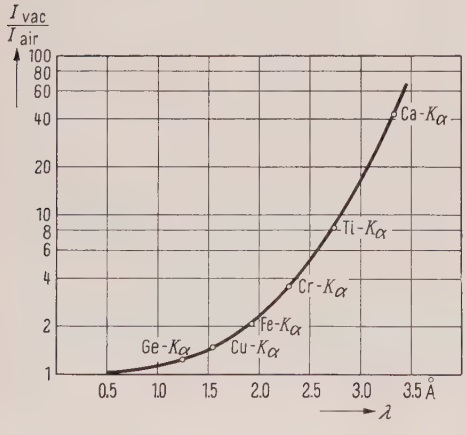


Fig. 3 Intensity gain I_{vac}/I_{air} upon evacuation of the spectrometer for wavelengths between 1 and 3 Å

λ Å	HIT cm	λ Å	HIT cm
1	186.6	4	3.89
1.2	111.7	5	2.03
1.5	59.0	6	1.20
2	25.6	8	0.53
2.5	13.4	10	0.28
3	7.93		

Table 1 Half-intensity thickness HIT in cm for wavelengths between 1 and 10 Å in air at a density of 0.00129 g/cm³

The fluorescence yield w_q is the ratio of the number of atoms n_{qf} which emit the characteristic spectrum of the q series, in relation to the number of atoms which are excited in the q shell: $w_q = n_{qf}/n_q$. The remainder of the atoms, $n_{qe} = n_q - n_{qf}$, dissipates its excitation energy by emission of secondary photoelectrons (Auger electrons) and is thus not available for the emission of the characteristic spectrum [2] (Fig. 2). As the atomic number decreases, the fluorescence yield decreases rapidly. While it is still 0.74 in the case of Mo, it drops to 0.26 for Cr, to 0.11 for K, and is as low as 0.025 in the case of Al. If the number of excited atoms were equal, the intensity of the Al-K_α line, as compared with the same line of Mo, Cr, and K, would be smaller by a factor of 30, 10, and 4, respectively.

The absorption. Since the absorption coefficients of x-rays [2, 3, 4] are proportional to $\varrho\lambda^3 Z^3$, the long-wave spectra of the elements with atomic numbers between 12 and 22 are so strongly absorbed by air that they can be observed only in a vacuum spectrometer (Table 1). Fig. 3 shows that even for the relatively short wavelengths of 1 to 3 Å (Ge to Ti), a considerable intensity gain can be obtained by evacuating the spectrometer. This measurement also takes into consideration the intensity loss of the exciting x-rays. For these wavelengths, operation in a vacuum has the additional advantage that atmospheric influences (humidity, pressure, temperature) are minimized or entirely eliminated. For the K_α radiation of Ti and V, such influences may result in measuring errors of as much as 5%. If measuring errors due to variation of the vacuum are to be held at 0.5%, then a vacuum of 10^{-1} mm Hg is required for the K_α radiation of Al and Mg. A change of the vacuum within the limits of 0.2 and 0.05 mm Hg would then result in measuring errors of −0.25 and +0.13%, respectively, in the case of the Al-K_α line. On the other hand, a change of the vacuum from 1 mm Hg to 2 or 0.5 mm Hg, respectively, would result in errors of − 4 or + 2.5%.

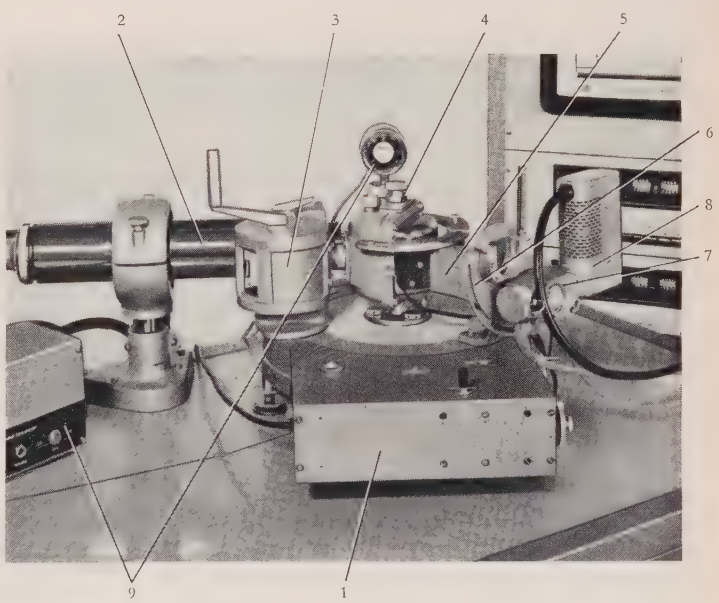
In the spectrometer described in the following, a vacuum of $5 \cdot 10^{-2}$ mm Hg can be reached by a combination of a rotary slide valve with a rotary pump having a limiting vacuum of approximately 10^{-3} mm Hg and a capacity of 2 m^3/hour and higher.

The Vacuum Spectrometer

The arrangement of the vacuum spectrometer is shown in Fig. 4. The components of the actual spectrometer can be readily attached to the goniometer, so that a rapid rearrangement is possible, for example, if the goniometer is to be used for microanalyses or as a diffractometer for x-ray diffraction investigations. The spectrometer consists essentially of the sample chamber, the crystal changer, the support for the Soller slit, and the detector holder. The x-ray tube which furnishes the primary radiation is attached rigidly and vacuum-tight to the sample chamber, so that the rays never leave the vacuum on their passage from the x-ray tube window to the detector window. The radiation from the x-ray tube falls horizontally upon the samples, which are held vertically in the sample chamber. The angle of incidence and the angle of reflection of the x-rays at the sample surface are 45°. The sample chamber contains three compartments which can be brought into the measuring position by turning a hand lever. A conical spring-lock is provided to make sure that the compartments are held at perfectly reproducible angles and, at the same time, to eliminate the possibility of accidental shifting. As a sample is placed into the sample chamber, only the small air volume of one compartment is introduced into the vacuum; as long as the vacuum pump is running, a vacuum of 10^{-1} mm Hg will be reached again within about 20 seconds after the sample has been introduced. This makes it possible to carry out analyses without any interruption whatever and with a minimum loss of time. If the sample chamber is pre-evacuated, the measurement can be carried out immediately after the sample has been brought into the measuring position. The time required to evacuate the whole spectrometer is less than two minutes. Samples with diameters up to 50 mm and thicknesses up to 20 mm may be analyzed. If powder samples are to be analyzed without the need of high precision, the samples can be poured into small polyethylene beakers, which are then covered with very thin Mylar films. However, a Mylar film of 6-μ thickness will absorb 50 and 75%, respectively, of the K_α radiation of Al and Mg. For analyses of elements with a low atomic number, and especially in the case of quantitative analyses where high precision is required, it is more advantageous to press the powders into pellets, using high pressures (1 to 3 tons/cm^2). Liquid samples may also be analyzed in these polyethylene beakers, which are resistant to most acids, bases, and organic solvents. However, since a number of liquids are not suitable for vacuum analysis (due to their high vapor pressures), the spectrometer is equipped for flushing with helium or hydrogen. Due to their low densities and atomic numbers, these gases absorb x-rays only very slightly. In order to reduce the gas consumption, the compartments of the sample chamber may be pre-flushed, so that no air is introduced into the measuring path. Furthermore, the volume of the sample chamber may also be separated (by means of a thin vacuum-tight film) from the rest of the spectrometer so as to minimize the absorption due to air. In that case, the path of rays is almost exclusively within the evacuated space.

By means of the crystal changer, the analyzer crystals, LiF and gypsum, can be brought into reflecting position within the evacuated section in such a manner that their angular ranges overlap perfectly. The LiF crystal (d = 2.01 Å) serves primarily to cover the K-spectra (λ = 2.8 to 0.3 Å) of the elements Ti to Nd (Z = 22 to 60) and the L-spectra (λ = 2.8 to 0.7 Å) of the elements Ba to U (Z = 56 to 92). The gypsum crystal (d = 7.6 Å) is provided primarily for the analysis of the K-spectra of the elements Mg to Ti (Z = 12 to 22, with λ = 10 to 2.5 Å). Therefore, this vacuum spectrometer makes it possible to analyze all elements with atomic numbers between 12 and 92.

After admitting air to the spectrometer and lifting the detector holder, two Soller slits with resolutions of 0.15 and 0.4°, respectively, may be interchanged; in this manner, it is possible to operate with that slit which is most suitable for any particular analysis. For example, if



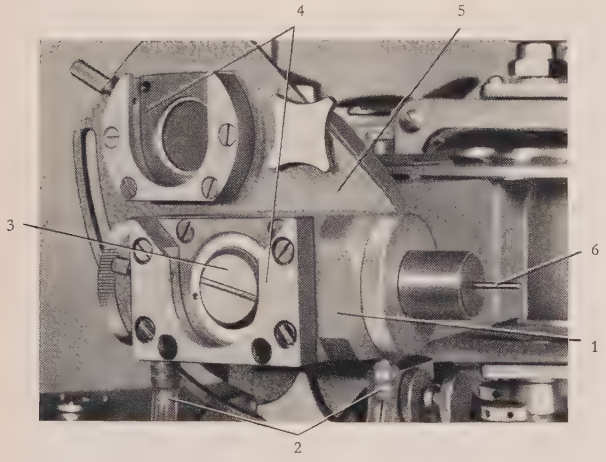
1 Goniometer
2 X-ray tube
3 Sample chamber
4 Crystal changer
5 Slot for the apertures (Soller slits)
6 Detector changer
7 Flow counter
8 Pre-amplifier
9 Bimetallic vacuum gauge

Fig. 4 Arrangement of the vacuum spectrometer

a particularly high resolution is not required, the 0.4° slit would provide an intensity twice as high as that obtainable with the 0.15° slit.

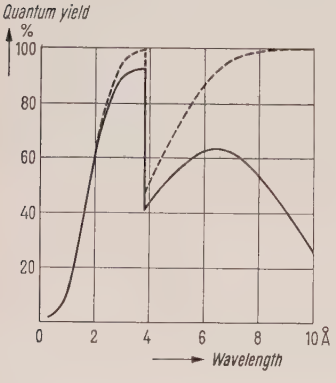
For the different applications, especially if measurements of short-wave spectra and very long wave spectra alternate, different detectors must also be used [5].

The interchange mechanism for the detectors makes it possible to rapidly interchange two detectors, such as a scintillation counter for short-wavelength radiation and the flow counter for long-wavelength radiation. Additional components in the radiation-measuring system make it possible to keep both detectors operating simultaneously and to switch the pulse-counting equipment of the radiation measuring device to one or the other of the detectors as required. Such an arrangement is of particular importance for routine analyses, because stable conditions are attained only after the pre-amplifier of the flow counter or the electron multiplier in the scintillation counter, respectively, has gone through a warm-up period. Furthermore, this arrangement makes it possible to connect both detectors to the pulse-counting equipment and, in this manner, to determine the sum of the pulses which accrue in both detectors.



1 Flow counter
2 Inlet and outlet for the gas mixtures
3 Counter-tube window (the film is covered by a protective screw)
4 Brackets for additional detectors
5 Interchange mechanism for the detectors
6 High-voltage terminal

Fig. 5 The flow counter at the detector changer of the vacuum spectrometer



– – – for gas absorption only
——— for gas absorption after reducing the intensity of the radiation by passage through a MYLAR film of 6-μ thickness

Fig. 6 Quantum yield in the flow counter

The Flow Counter

To detect x-rays with wavelengths between 3 and 10 Å, the counter tube must be equipped with an especially thin window of a material which is transparent for these wavelengths. The mica and beryllium windows of the common counters absorb these long wavelengths to such an extent that it is no longer possible to measure this type of radiation. At the same time, due to the thermal noise of the secondary electron multiplier and due to the extremely low light yield of the scintillation crystals at these wavelengths, scintillation counters are of no use at wavelengths below approximately 3 Å. Therefore, a counter tube with a window consisting of a 6μ-thick MYLAR film was developed to measure in the wavelength range between 3 and 10 Å. As films of this thickness are no longer vacuum-tight, the composition of the gas in the counter tube would be changed within a short time and the counter tube would rapidly become useless. Therefore, a stream of a gas mixture consisting of 90% argon and 10% methane is passed through the counter tube at atmospheric pressure. A gas flow rate of approximately two liters per hour is required for satisfactory operation. No particular difficulty is encountered here, since both argon and methane are commercially available in pure form. A compressed-gas cylinder of 50-liter volume, filled at a pressure of 200 kg/cm², will suffice to operate the counter tube for 5,000 hours.

Fig. 5 shows the flow counter attached to the detector changer of the spectrometer. The counter tube is designed as a transverse counter; to eliminate reflection effects, the back wall is also provided with a window made from a thin film. Short-wavelength components of the radiation which are not absorbed in the counter tube can leave the counter tube through this window. These components may then be measured by means of a second detector (sensitive for short-wave radiation) which may be mounted in the bracket provided at the back window of the counter. Such an arrangement has a dual advantage: on the one hand, the necessity of changing detectors is eliminated and, on the other hand, the sum of the radiation absorbed in the two detectors can be obtained. Fig. 6 shows the quantum yield of the flow counter as a function of the x-ray wavelength. Even at the shorter wavelength, the flow counter tube still provides a high quantum yield. Even at wavelengths as low as 1.5 Å, it is entirely equivalent to all other types of counter tubes. In combination with a scintillation counter (which is particularly suitable for operation at wavelengths below 2 Å), it is thus possible to obtain optimum coverage of the whole range of wavelengths which are encountered in fluorescence analyses.

Due to the superposition of the long-wavelength lines of low-intensity spectra with higher-order lines of short-wavelength spectra of the elements contained in the sample, and due to the high background scatter, the flow counter will usually be operated in the range of proportionality when making analyses for elements with a low atomic number (Mg through Ca). Depending on the energy of the x-rays absorbed* [1], pulses of different voltages are generated in the counter tube; after amplification in a linear amplifier, these pulses can be measured by means of an electronic pulse-height analyzer (differential discriminator). As a result of the particular discharge mechanism in the counter tube, the pulse heights for quanta of equal energy which enter into the counter tube exhibit a statistical variation around a mean value. The pulse-height distributions of the flow counter tube for the K_α radiation of Al, Ca, and Fe, respectively, are shown in Fig. 7. The obtainable resolution is indicated by the half-height widths of these distributions, as shown in the graph. Fig. 8 shows the linear relationship between the energy of the x-ray quanta and the measured pulse height. All undesirable radiation components can be suppressed by filtering out a certain pulse height, so that the sensitivity for the measurement of individual lines can be greatly increased.

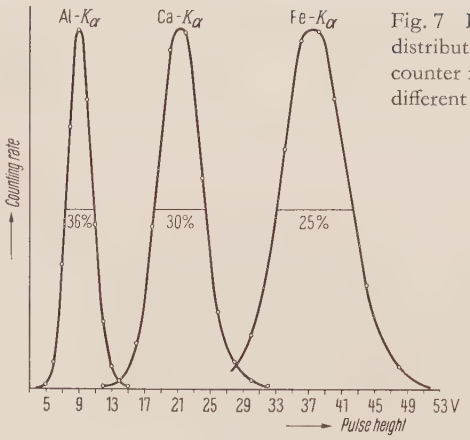


Fig. 7 Pulse-height distributions in the flow counter for x-rays of different energy

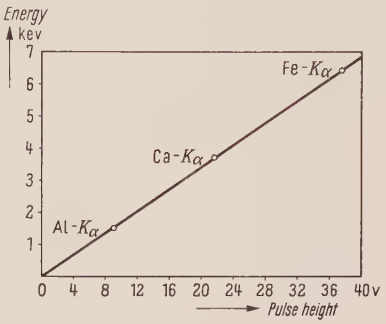


Fig. 8 Energy proportionality of the x-ray quanta with the measured pulse heights

Fig. 9 shows the complete assembly of the measuring equipment for x-ray fluorescence analysis, with the Kristalloflex 4** x-ray unit, the vacuum spectrometer, and the radiation measuring device with potentiometric recorder mounted into a cabinet with attached count-time print-out device.

Qualitative Analyses

Examples of qualitative analyses in the range of the elements 12 through 22 are shown in Figs. 10 and 11. To obtain the spectrum of the slag, the differential discriminator was adjusted in such a way that the short-wavelength radiations (especially the Ca radiation, which, due to high concentration, was particularly intense) were considerably reduced while the Mg and Al radiations were measured at full intensity. Fig. 12 is an example of the line intensities which are still visible.

Quantitative Analyses

For quantitative analyses, the intensity of the spectral lines is determined by counting the voltage pulses which are triggered off in the detector within a certain counting period [1,5]. If this counting is carried out over a sufficiently long time interval, the number of pulses will be large enough to achieve a satisfactory precision in accordance with statistical laws (6 to 11). The error (standard deviation) of a pulse count is $\sigma = \pm\sqrt{N}$, where

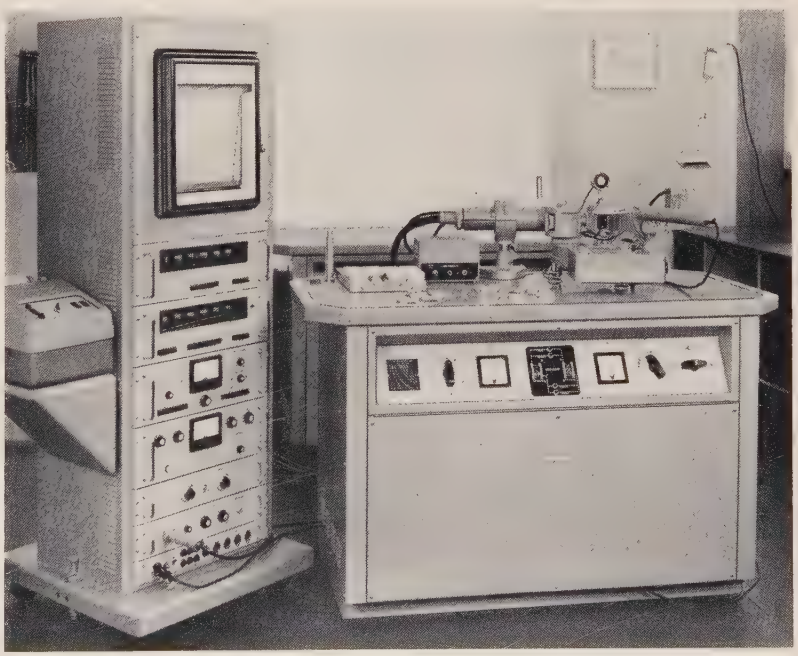


Fig. 9 Complete measuring equipment for x-ray fluorescence analyses

* According to the Einstein equation $E = h\nu = \frac{hc}{\lambda}$, the energy E of an x-ray quantum is inversely proportional to the wavelength.

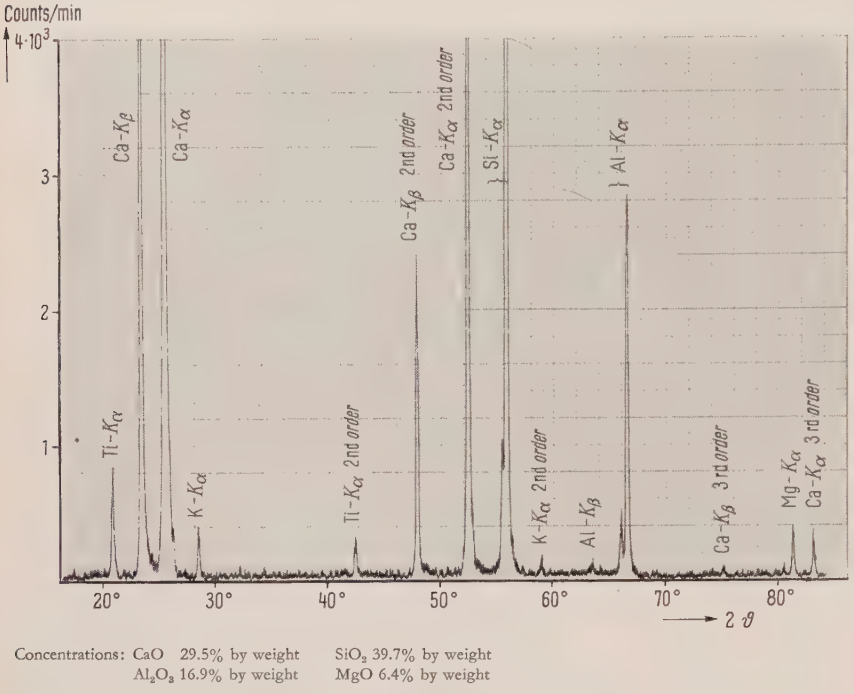
** Trade-mark

N is the measured number of pulses. From this it follows for the relative mean error (relative mean square error, relative standard deviation) $\varepsilon = \pm\sqrt{N}/N = \pm 1/\sqrt{N}$, or, expressed in per cent of N, $\varepsilon = \pm 100/\sqrt{N}\%$. If the background count, N_0, is taken into consideration, the mean square error for the measurement of the net number of pulses, N_l, of a spectral line is given by $\sigma_l = \pm\sqrt{\sigma_0^2 + \sigma^2}$, where σ_0 and σ are the mean square variations for the measurement of the background count, N_0, and of the total number of pulses, N. If equal measuring intervals are used for N and N_0, it follows from the discussion above that

$$\sigma_l = \sqrt{N_0 + N}$$

To obtain the relative error, the calculation must be based on the net number of pulses: $\varepsilon = \pm\sqrt{N_0 + N}/N_l$. Expressed in per cent of N_l, we thus obtain $\varepsilon = \pm\sqrt{N_0 + N} \cdot 100/N_l$. In the first approximation, a reduction of the relative error by a factor of two thus requires that four times as large a number of pulses be counted, for example, by extending the measuring time by a factor of four.

Figs. 13a through 13c show calibration curves for the elements P, Si, and Mg as they were obtained during analyses with the vacuum spectrometer. All analyses were carried out using a high-power x-ray tube, type AG Cr 60, at a load of 1300 watts (state of development: summer 1960). In each case, the abscissa shows the concentration in per cent by weight of the respective element, while the gross pulse count (line plus background) during the test interval is shown as the ordinate. The background count can be obtained by extrapolating to the concentration zero. By means of these calibration curves, it is possible to calculate ε for any desired concentration. Table 2 shows some examples of calculated ε-values. For the recording of the analytical results and for reducing the work load on the operating personnel, the count-time print-out device (see Fig. 9) has been found to be very useful. It records, besides a current event number, the number of pulses counted by the radiation measuring device and the pertinent measuring time.



Concentrations: CaO 29.5% by weight SiO_2 39.7% by weight
Al_2O_3 16.9% by weight MgO 6.4% by weight

Fig. 10 Recording of the spectrum of a furnace slag in the range of the K-spectra of the elements Ti through Mg, obtained with the vacuum spectrometer

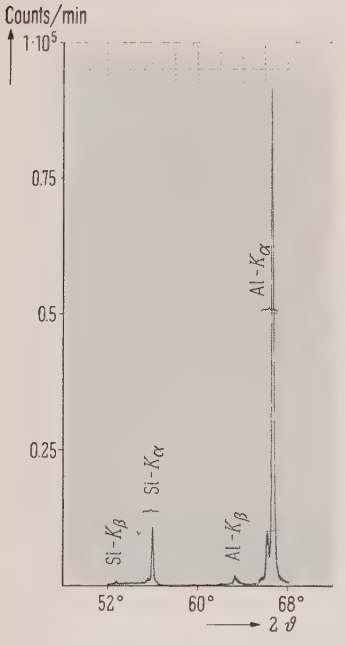


Fig. 11 Recording of the spectrum of an Al-Si casting alloy in the range of the K-spectra of the elements Si and Al, obtained with the vacuum spectrometer

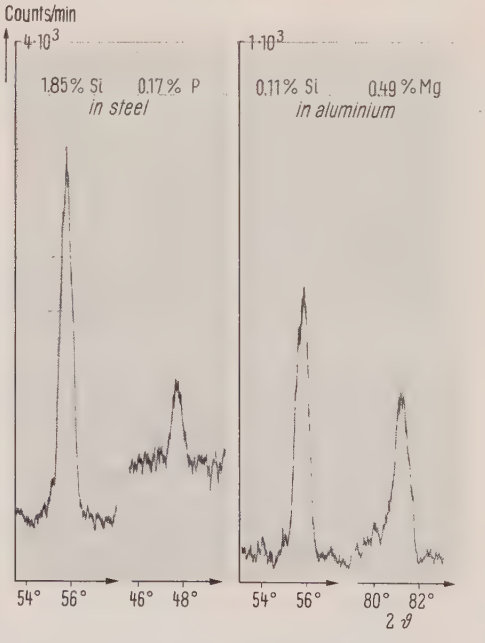


Fig. 12 Examples of the lines of the elements P, Si, and Mg at low concentrations

The Lowest Detectable Concentration

Another quantity which is of importance for the analysis and which characterizes the usefulness of the method is the lowest detectable

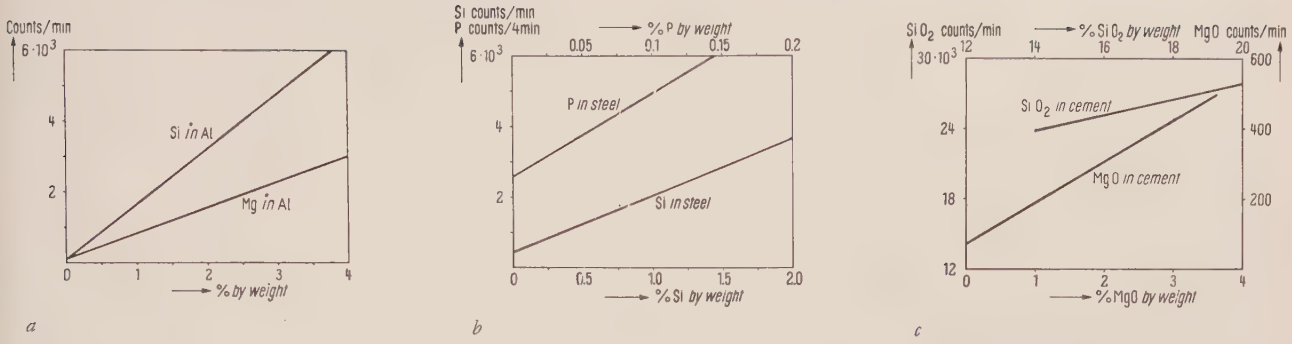


Fig. 13 Calibration curves for the elements P, Si, and Mg, and for the oxides SiO_2 and MgO in various materials. The concentrations in per cent by weight are shown on the abscissa, and the gross pulse counts obtained during the measuring time are shown on the ordinate

Analysis for	Concentr. % by wt.	Sample	Meas. time min.	ε* %	ε** % by wt.
Si	1	Al	1	2.64	0.026
Mg	3	Al	1	2.20	0.067
Si	1	Steel	1	3.05	0.030
P	0.119	Steel	4	3.30	0.004
SiO_2	22.2	Cement	1	0.60	0.130
MgO	2.54	Cement	1	7.00	0.175

* In per cent of the concentration
** In absolute per cent by weight

Table 2 Mean per cent error during the x-ray fluorescence analysis for the elements P, Si, and Mg, as well as for the oxides SiO_2 and MgO at low concentrations (for measuring times as shown in the table)

Analysis for	Sample	Meas. time min.	Lowest detectable concentration, % by wt.
Si	Al	1	0.016
Mg	Al	1	0.039
Si	Steel	1	0.038
P	Steel	4	0.006
SiO_2	Cement	1	0.025
MgO	Cement	1	0.210

Table 3 Lowest detectable concentrations with x-ray fluorescence analysis for the elements P, Si, and Mg and for the oxides SiO_2 and MgO (for measuring times as shown in the table)

concentration for an element during a given measuring time. This quantity depends on the background pulse count at the position of the spectral line which is to be analyzed [5, 6, 10] and on the slope of the calibration curve, $\Delta N/\Delta C$, at the concentration $C = 0$.

A spectral line with the gross pulse count N^* is regarded as being significantly different from the background pulse count N_0 if the difference $N - N_0 = 3\sigma_0 = 3\sqrt{N_0}$**. This, however, requires that N_0 be a rather precisely known average from a number of measurements, a condition which is usually fulfilled.

* Equal measuring times for N, N_0, and N_e being considered.
** A Gaussian distribution of the pulses being assumed.

If the net pulse count N_e for a small concentration C is known, then the limiting concentration (lowest detectable concentration) C_g can be calculated by linear interpolation of the pulse counts: $C/C_g = N_e/3\sqrt{N_0}$. A number of such lowest detectable concentrations, with the pertinent measuring times, which were calculated in this manner are compiled in Table 3.

These examples show that, as compared with other analytical methods, the x-ray fluorescence analysis for the elements between Mg and P is capable of providing satisfactory analytical precision within relatively very short measuring times. For the majority of actually occurring problems, the lowest detection limits are satisfactory. The x-ray fluorescence analysis, as a purely physical measuring technique, is particularly suitable for routine analyses because of the simplicity of the measurement and of the low manpower requirements. For example, the x-ray fluorescence method is of outstanding importance for the analysis of slags, cement, and glasses, which are very difficult to analyze by the conventional chemical methods and almost impossible to analyze by the methods of optical spectroscopy.

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Cables with Continuously Extruded Aluminium Sheaths

BY HANS BORCHARDT AND WALTER THELE

In the manufacture of cables the influence exercised on the properties, life and costs of the product by the production methods employed is greater than that in any other branch of the electrical industry. It was this fact, substantiated many times over, which prompted the House of Siemens right from its early days to the present to carry out technical development work on a broad basis. One of the results of this is a method introduced some twenty-five years ago for the direct extrusion of aluminium sheaths onto cable cores. The completion of the difficult task of extruding the sheaths in a continuous process now represents the final stage in this development.

Direct extrusion of aluminium sheaths onto cable cores

In 1851 WERNER SIEMENS succeeded for the first time in drawing insulated conductors into lead tubing and in working the lead to form a close fit. Shortly after this, the SIEMENS and BORELL method was devised and applied for the direct extrusion of lead sheaths onto cable cores. Following these developments, the conventional lead-sheathed cable predominated in all fields of communication and power engineering for almost a century.

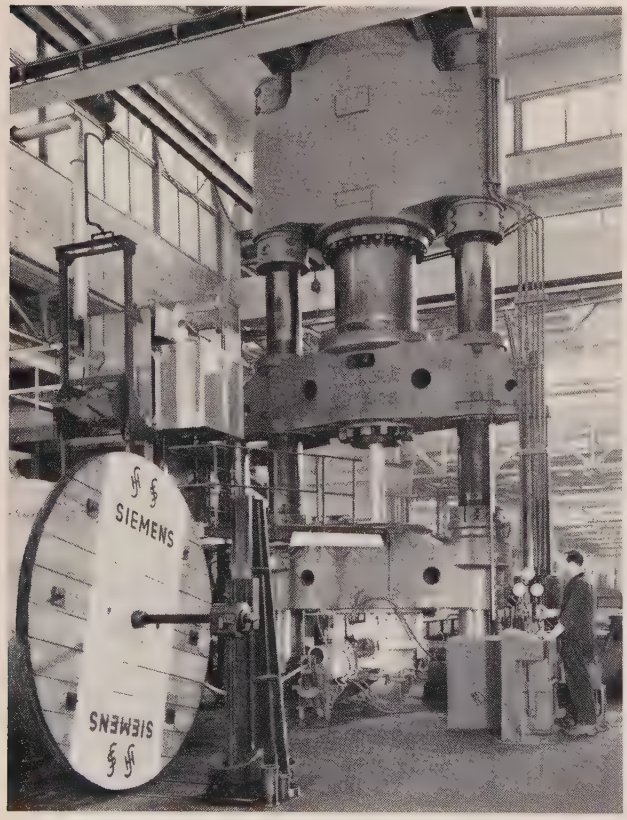


Fig. 1 3,800-ton press before conversion

It is only in recent decades that new thermoplastics and new methods for the processing of metal have paved the way for new development trends in the sheathing of cables.

Of the new designs of metal sheaths, thermoplastic sheaths and combinations of both, aluminium sheaths have scored the greatest success in many fields of application.

Work on the sheathing of cables with aluminium first started in the cable works of Siemens-Schuckertwerke in Berlin over thirty years ago. To begin with, it consisted in the continuous longitudinal welding of tubes formed round the cable core by strips of aluminium. A few years later this method was superseded by direct extrusion of aluminium in a manner similar to that employed with lead-sheathed cables. The first report on this was published in 1939 [1]. Despite the difficult conditions brought about by world affairs, a combined effort of Siemens-Schuckertwerke and Krupp-Grusonwerk resulted in the commissioning in 1941 of a 3,140-ton extruding press. This press, the first of its kind in the world, was used until 1945 and provided valuable data and experience for subsequent work [2]. At the end of the war the press was taken out of the works but is still in operation elsewhere.

In the course of the reconstruction of the cable works in Berlin, Siemens-Schuckertwerke decided to continue with the development work and in the spring of 1952 an improved 3,800-ton cable sheath extruding press built by the Hydraulik GmbH, Duisburg was put into operation. A report on the stage of development at that time and on the possibilities of this plant was given in 1953 [2].

The advantages of aluminium sheaths over lead sheaths lie not only in the mechanical properties but also in the electrical characteristics [1 to 5]. The mechanical strength of aluminium is appreciably greater and in many cases obviates the need for additional armouring. Referred to volume or unit length both price and weight are lower. The aluminium sheath is completely impervious to liquids and

vapours and it has a fully adequate degree of flexibility, which, in the case of very large cable diameters, can be increased by peripheral corrugation. The application of suitable coverings provides reliable protection against corrosion which has proved highly satisfactory, even under severe operating conditions.

The good electrical conductivity of aluminium has made possible the adoption of a proposal put forward by Siemens-Schuckertwerke, namely that the aluminium sheath be used as the neutral conductor in three-phase a.c. systems. This has resulted in an appreciable reduction in costs.

The high conductivity also makes for a much better reduction factor than is the case with lead and steel sheaths, an advantage which has procured for aluminium-sheathed communication cables a prominent place in the selection for use in the interference range of parallel high-voltage lines, e.g., on electrified railways.

In the meantime many other special machines have been constructed by German engineering firms on the pattern of the first press installed in the Siemens-Schuckert cable works.

The almost insurmountable difficulties which are confronted in the use of liquid aluminium were revealed during the first extrusion attempts in the thirties. Unfavourable effects were introduced by the formation of blow-holes on the setting of the aluminium in the press receiver and by the solubility of steel in liquid aluminium. For this reason the extruding presses have since been operated with round aluminium billets at a temperature of approximately 400 °C. Various methods have been employed to eliminate the inclusion of air during the upsetting of the aluminium billet in the receiver, a condition which may give rise to faults in the aluminium sheath. Attempts were made, for instance, to discharge the air through V-shaped longitudinal grooves in the sheath surface of the billet. Another method is differential heating of the aluminium billet in the longitudinal direction with the object of influencing the upsetting properties in such a manner that the billet in the receiver is worked conically, thus permitting the air to escape at the intake side. The most effective method, however, is to remove the air from the receiver as is done in a process developed by Siemens-Schuckertwerke in which the receiver is sealed off with an aluminium disc and evacuated after being charged. Under the compression of the press the aluminium disc welds itself to the aluminium billet and is extruded with it [6]. This method has been successfully used for many years and reliably eliminates defects in sheaths due to the inclusion of air.

During each stroke, hydraulic presses process a limited volume of material which is determined by the design of the press and the capacity of the receiver. At the beginning it was considered sufficient to so fix the cable length as manufactured that the volume of material required for the sheath did not exceed the capacity of the receiver. In time, however, this method was no longer able to satisfy the requirements of customers. As is the case with lead sheaths, an attempt was therefore made to manufacture longer single lengths by repeated refilling of the receiver. With aluminium, however, this is more difficult since it is necessary to use much higher working pressures and processing temperatures.

To refill the receiver, the press ram had to be withdrawn. The full release of the pressure in the press not only meant a stoppage in production but also gave rise to appreciable changes in the stresses in the ram and in the press tools. These elastic changes in the deformation of the tools, whose clearance is decisive for the wall thickness of the extruded cable sheath, caused a clearly marked contraction in the sheath, the so-called stopping point (Fig. 2).

During the period of stoppage, the insulation of the cable is exposed to the thermal effects of the press tools which have a temperature of 400 to 450 °C. Unless protective measures were taken, the conventional material used for cable insulation would be damaged by the heat. Expensive equipment had to be employed to overcome this difficulty.

In view of this, endeavours were made at an early stage to perfect the direct method of extrusion of aluminium sheaths by converting it into a continuous process; towards this end, Siemens-Schuckertwerke carried out extensive experimental work in their own works.

The results of this work pointed to two possible solutions:

The application of the screw-press technique, successfully used for the extrusion of lead and thermoplastic sheaths;

The redesigning of hydraulic presses with one or several receivers for fully continuous extrusion of the sheath.

Experiments with screw extrusion presses have as yet not produced any practicable solution since the tool steels available do not appear capable of withstanding the enormous forces required for working the material. Thus all efforts were concentrated on the other possible solution, the hydraulic press technique.

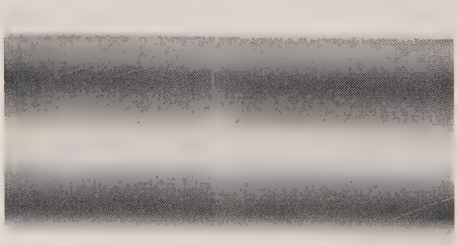


Fig. 2
Stopping point in an aluminium sheath

Following work and experiments on a design which held out good promise, the Hydraulik GmbH put forward a proposal for the conversion to continuous operation of the existing single-ram press in the Berlin cable works.

To keep to their tradition and make a further contribution to progress in cable engineering, Siemens-Schuckertwerke again decided to accept the risk of employing a new untried technique in actual production by agreeing to the expensive conversion of the 3,800-ton press.

The order was duly placed and completed in the period from November 1959 to January 1960. All aluminium-sheathed power and communication cables produced from that date onwards have been sheathed by this new method.

Construction and mode of operation of the continuously operating extrusion press

Figs. 1 and 3 and the colour photograph opposite page 137 show the press before and after conversion. The 3,800-ton press is of the hydraulic double column type. The hydraulic cylinder is arranged at the top and is firmly clamped between the columns by ring nuts. The vertically moving crosshead which carries the hydraulic plunger at the top and the ram at the bottom is connected to the retraction pistons by means of the two side projections.

Before the conversion was carried out, the lower support, which rested on the foundation below the floor and which was likewise connected to the columns by ring nuts, carried the press block and the receiver crossbeam connected to this (see Fig. 1). In the conversion to a continuous process, these were replaced by a 35-ton cast-steel frame arranged between the columns (see Fig. 3 and colour photograph opposite page 137). The lower part of the cast-steel frame is designed in the form of a hydraulic cylinder and is rigidly connected to the lower support. Screwed to the upper part of the frame is the receiver and in the middleis the press block.

When the press was converted, a new Siemens induction furnace was installed for heating the billets (Fig. 4). The three-phase induction unit, operating at industrial frequency to provide better penetration, has a useful output of 150 kW and takes a load of 450 kVA. Within a period of three to four minutes the aluminium billets can be heated to a temperature of 350 to 450 °C. The timing cycle of the furnace is set to suit the maximum output of the press. Aluminium of highest purity is used or aluminium as defined by German Industrial Standards DIN 1712.

The controls for the induction furnace and for the press pumps are combined into a single control desk (Fig. 5). The charging process is carried out automatically following the pressing of a pushbutton by the operator. It can be checked on a luminous control diagram.

All the control and measuring equipment for the heating of the press and the recording instruments for registering the hydraulic pressure and temperature of the press are accommodated in a control cubicle (Fig. 6).

A cold aluminium billet is lifted from a truck by a piston arranged under the floor and placed in the induction furnace; at the same time this forces the aluminium billet, which has been raised to operating temperature, out of the induction coil. It is then gripped by a swivel arm and lifted over the receiver. The billet is then released and drops into the receiver which is sealed off with an aluminium disc.

Arranged in the hydraulic cylinder in the cast-steel frame (part 3 in Fig. 7) is a lower hydraulic plunger (10), on this the press block (9) with the antechamber (8). The connection between the antechamber and the valve body (5) and with the receiver is made through the bore of the

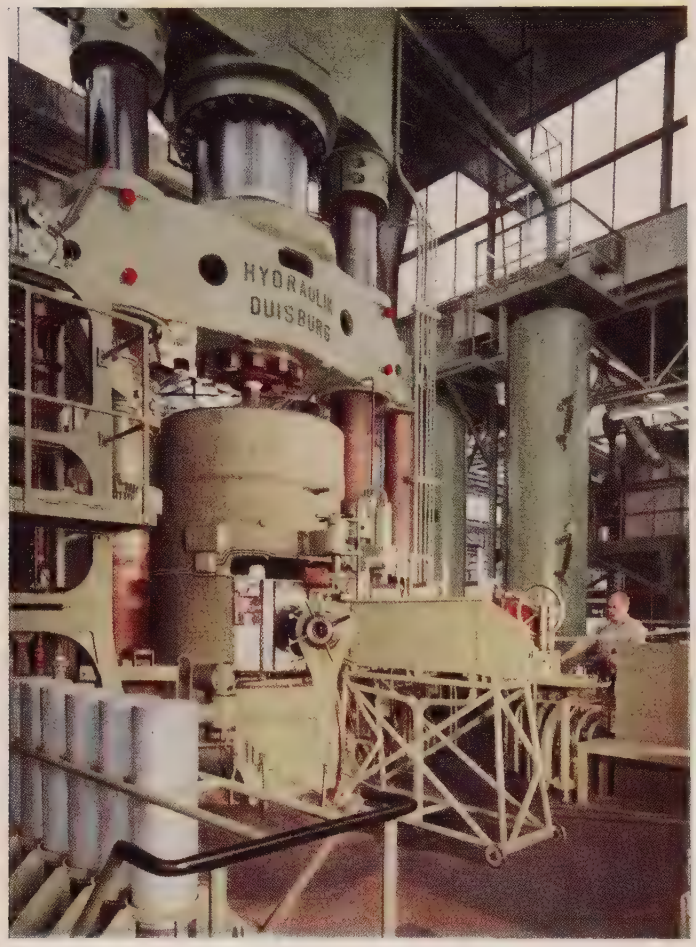


Fig. 3 3,800-ton press after conversion

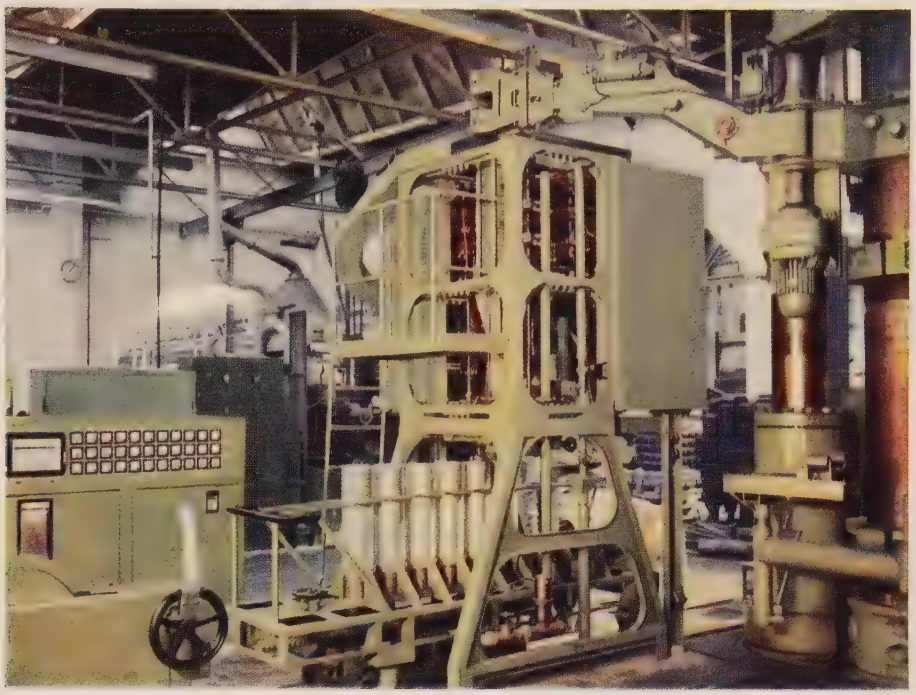


Fig. 4 A Siemens induction furnace for heating aluminium billets

hollow ram (7). Built into the valve body is a floating valve (6). This is designed to permit the aluminium to flow downwards from the receiver, any flow of metal back into the receiver being prevented when the valve is in the raised position (Fig. 8). The valve body and the receiver are firmly screwed into the cast-steel frame.

Extruding begins when the plunger (part 1 in Fig. 7) is forced down with the ram (2). The ram firmly presses the aluminium disc against the receiver and after the latter has been evacuated impacts on the aluminium billet forcing the aluminium out of the receiver. The aluminium flows past the open valve (6) through the hollow ram (7) into the antechamber (8) and further through ducts to the tools which give the sheath its shape. It leaves the annular gap between these tools in the direction of travel of the cable core, which lies at right angles to the axis of the press, and tightly sheaths the cable cores.

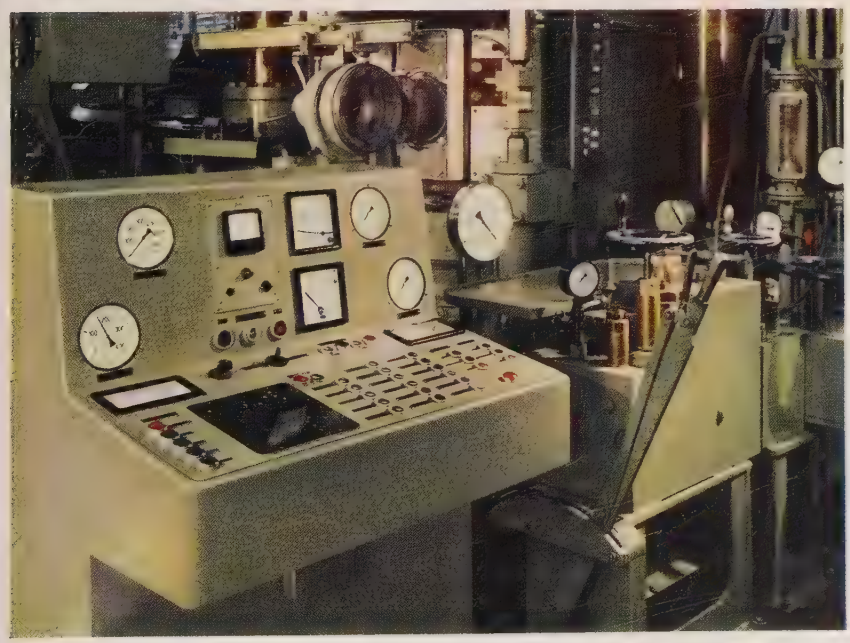


Fig. 5 Desk for controlling the induction furnace and the hydraulic pumps

Material	Al 99.5	Al 99.8	Al 99.99	Copper (tape, soft)	Steel (tape, soft)	Lead
Specific weight ..... g/cm³	2.7		2.699	8.93	7.86	11.34
Melting point ..... °C	658		660	1,083	1,528	327
Boiling point ..... °C	2,270		2,270	2,336	2,900	1,652
Extruding temperature ..... °C	450	400	350	800		200
Strength ..... kg/mm²	Tape 7 to 7.5	Cable sheath extruded 6.0 to 7.5	4 to 5	22 to 25	33 to 38	1.2 to 1.4
Yield point ..... kg/mm²	3.9 to 4.3	5 to 6	2.6 to 3.5	7 to 9	27 to 32	0.5 to 0.6
Elongation (= 10 d) ..... %	25 to 30	25 to 35	30 to 35	40	35 to 40	30 to 50
Endurance limit ..... kg/mm²	2.7			7.4	≈ 20	0.25
Hardness ..... kg/mm²	18 to 20	16 to 18	12 to 16	45 to 50	50 to 70	3.5 to 5
Electrical conductivity ..... Sm/mm²	≈ 36		≈ 37.5	58	8	4.8

Table 1 Properties of metallic cable sheathing materials

A water-cooled tube on the intake side of the press block (temperature 400 °C) protects the cable core against heat radiation. Immediately following extrusion, the aluminium sheath is thoroughly cooled so that the cable core is exposed to high temperatures over a short section only which quickly passes through the press.

When all aluminium has been pressed out of the receiver, hydraulic pressure is applied to the lower plunger, thus forcing the press block (part 9 in Fig. 8) upwards. During the operation of the upper ram the valve (6) is caused to move upwards under the effect of the aluminium forced back from below, thus closing the receiver. At the same time the block (9) presses against the hollow ram (7) thereby maintaining the pressure on the aluminium and forcing it out of the antechamber to the sheath-forming tools. The capacity of the antechamber is such that it permits the receiver to be charged with a new billet, without having to interrupt the extrusion process. In each new operating cycle the antechamber is refilled by the gradual lowering of the press block while at the same time the sheathing of the cable cores continues. Fig. 9 shows the curves for the pressure and speed in the discontinuous and continuous processes.

Thus the elimination of the stoppages makes the process continuous. The press block permits the extrusion of cable sheaths up to an outer diameter of 120 mm (4.7 in.). In the course of a few months more than 500 km (310 miles) of cable have been sheathed by this method.

Features of cables with continuously extruded aluminium sheaths

The physical and technological properties of aluminium and their utilization in the sheathing of cables have been described in detail in earlier publications [1, 2, 7 to 10].

Cables with directly extruded aluminium sheaths have been in operation for many years and have given satisfactory service. The technical features need not therefore be dealt with in detail here. In Table 1, a comparison is made of some of the physical data of aluminium and those of other metals which are used as cable sheaths [11].

The method of continuous extrusion provides both the manufacturer and the customer with a number of advantages. These are:

Uniform wall thickness of the aluminium sheath over the entire cable length

Improved bending properties of the sheath

Omission of expensive layers of material to provide protection against excessive thermal stressing

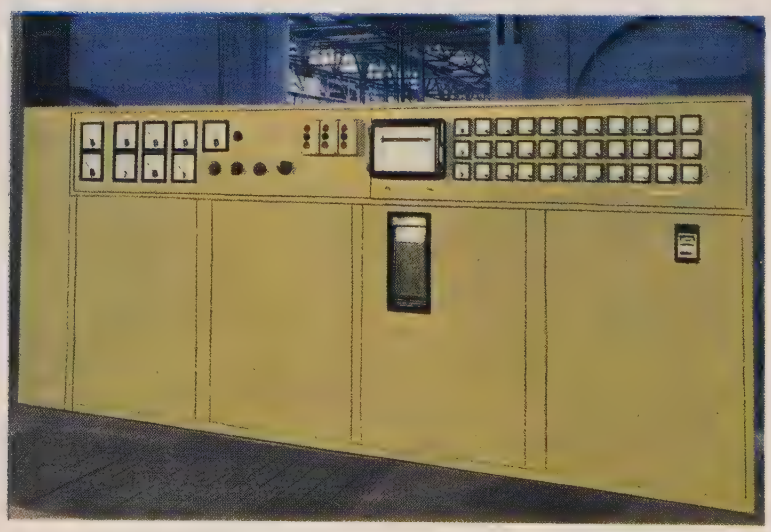
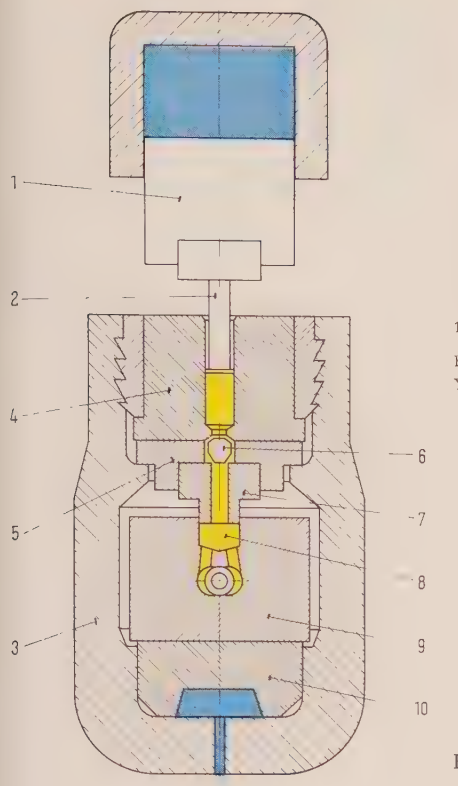


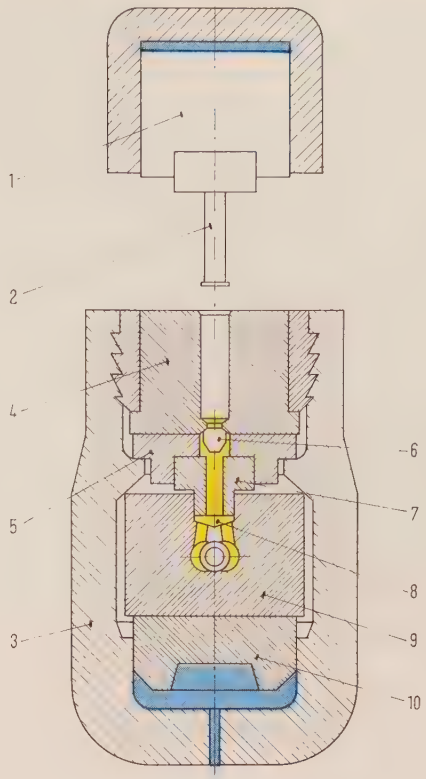
Fig. 6 Control board with control and measuring devices



1 Upper plunger
2 Ram
3 Cast-steel frame
4 Receiver
5 Valve body
6 Valve
7 Hollow ram
8 Antechamber
9 Press block
10 Lower plunger

Blue = Pressure water
Yellow = Aluminium

Fig. 7 Pressing



1 Upper plunger
2 Ram
3 Cast-steel frame
4 Receiver
5 Valve body
6 Valve
7 Hollow ram
8 Antechamber
9 Press block
10 Lower plunger

Blue = Pressure water
Yellow = Aluminium

Fig. 8 Pressing and recharging

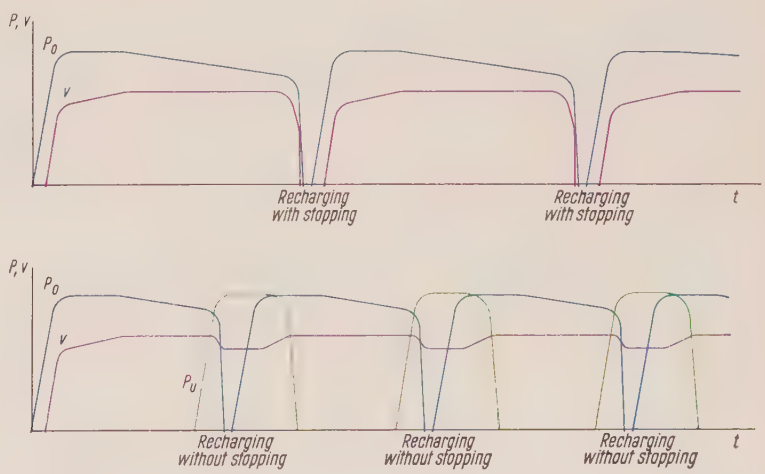
Higher degree of reliability in the manufacture and installation of cables and the possibility of sheathing cables with insulation which is very sensitive to heat.

With the discontinuous method, the reduction of the wall thickness at the stopping point (Fig. 2), which could have an unfavourable effect on the bending properties of the cable, was eliminated by adjusting the tools on the press and reinforcing the aluminium sheath. This reinforcement of the sheath, however, resulted in a reduction in the internal diameter of the sheath. The associated pressure of the hot aluminium sheath on the cable core increased the thermal stresses on the cable insulation.

This momentary exposure to heat has relatively little effect on paper insulation. In the case of thermoplastic insulation, however, it was necessary to provide an effective heat-resistant bedding. This can now be reduced appreciably or be omitted altogether. Thermoplastic, which is very sensitive to heat, can also be sheathed continuously. The possibility of irreversible changes in the condition of the material under the effects of pressure or chemical action, such as premature aging or brittleness due to thermal influences, is precluded.

The uniform wall thickness of continuously extruded aluminium sheaths over the entire length of the cable improves the bending properties and makes possible the use of cable drums with a smaller core diameter and a higher capacity.

The elimination of complicated cooling and adjusting devices on the press has reduced the requirements made on the operating personnel with regard to skill and alert-



P_o Upper plunger pressure P_u Lower plunger pressure V Extrusion speed

Fig. 9 Schematic representation of the extrusion pressure and speed with discontinuous (top) and continuous (bottom) processes

ness. The higher degree of reliability in the manufacture of the cable eliminates unduly high thermal stresses and makes the cable more reliable in operation. Long single lengths of cable to order and full utilization of the cable drum capacity simplify transport and storage conditions.

Future developments

In all branches of engineering the progressive improvement in designs and the endeavour to find the best possible solution for each individual case inevitably leads to an about-turn from conventional methods. In the cable industry, too, the conventional lead sheath will gradually be replaced by a variety of sheath designs. Insofar as it is necessary for electrical or mechanical reasons to provide the cable core with a strong and completely impervious sheath, i.e., a metal sheath, the direct and continuously extruded aluminium sheath holds out good promise for a wide variety of applications. Details of the successful application of aluminium-sheathed cables and of the ever increasing field for which they can be used will be contained in subsequent publications.

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(All of the authors listed have extensive experience in the manufacture and application of aluminium-sheathed cables)

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New Monitors for Pressure, Temperature and Level

By Richard Spiess

Monitoring devices are used in all applications where it is required that values and quantities be kept to within preset maximum and minimum limits.

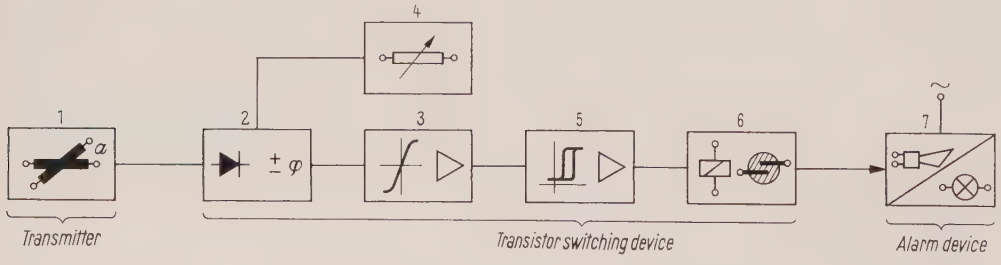
A characteristic feature of monitors is that, in contrast to indicators and recorders, they initiate an alarm signal such as a horn or flashing light, thus warning the operating personnel and enabling them to take the necessary action. In addition to merely initiating an alarm, monitors can in many cases be used to take direct action by shutting down the plant, for instance, or by removing the danger by operating a positioning element such as an emergency drain valve or a pump.

This turns the indirect-acting supervisory device into a direct-acting control or regulating unit. Under certain conditions, the monitor can be used as a simple two-step controller or also as a three-state controller [1 to 6].

Monitors should detect incipient faults and take immediate action to prevent any damage to the process to be supervised. With supervisory devices special attention must be paid to operational reliability since, in contrast to the majority of control devices, monitors are often not called upon for years. When the preset limit value is exceeded, however, they must function immediately and reliably.

The monitors described below for pressure, temperature and level have been developed from building blocks of the Teleperm* Z-system [7, 8]. Although the equipment has been designed primarily for use in thermal systems, particularly in steam power stations [9], where high pressures and temperatures are encountered, it can be employed for supervisory functions in all other branches of industry.

* Trade-mark



1 Pressure transmitter with inductive pick-off
2 Demodulator
3 Transistor input amplifier
4 Reference-value setter with calibrated scale
5 Transistor snap-action amplifier
6 Reed-contact output
7 Alarm device

Fig. 1 Functional scheme of the pressure monitor

The monitors are distinguished not only by robust mechanical construction but also by a high degree of operational reliability afforded by the use of modern electronic components.

The values are measured and evaluated continuously and, with the exception of the reed contacts in the output circuit, contactlessly. The reed contacts [10] are operated directly by a magnetic field and are not affected by the position in which they are installed. They have short switching times, are insensitive to vibration and are fully sealed off from the atmosphere. Positive and reliable switching is ensured by the snap-action operation of the contacts.

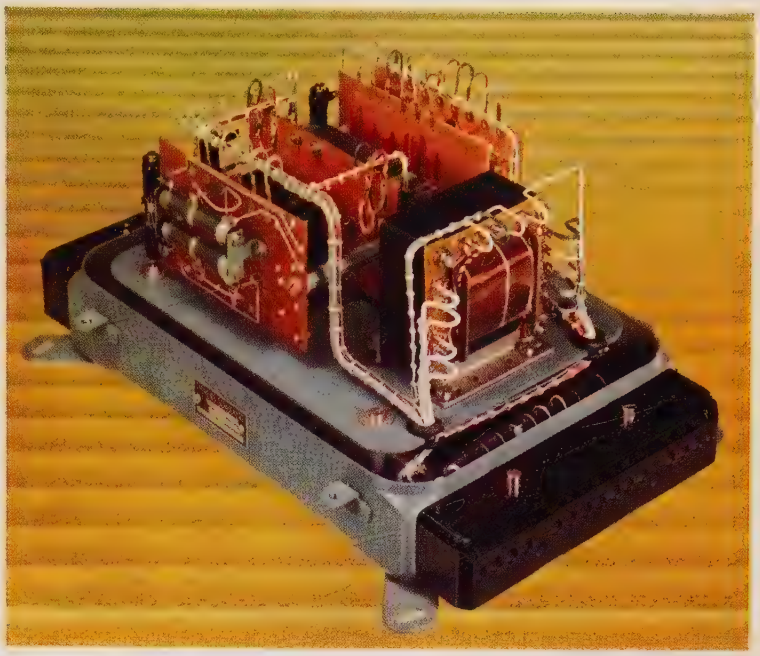


Fig. 2 Transistor switching device (cover removed)

Pressure monitor ZR-WD

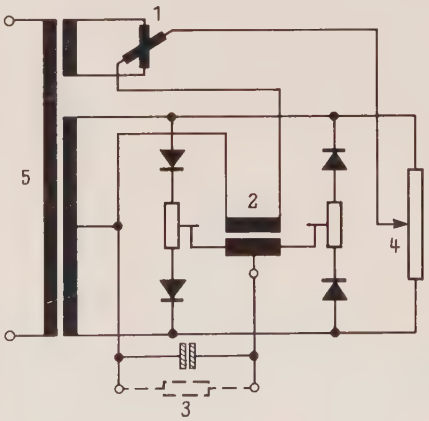
Pressure monitor ZR-WD consists of a pressure transmitter with an inductive pick-off, a transistor switching device and, if required, a separate power supply unit for feeding the system in the event of mains failure (Fig. 1). In the pressure transmitter the pressure is measured continuously and converted into an a.c. voltage by the inductive pick-off (inductive angular displacement transmitter), this voltage being fed to the transistor switching device. The measuring unit of the transmitter consists of a Bourdon tube the movement of which is transmitted via levers and gears (sensitive shock-proof measuring element used with turbines) to the rotor of the inductive angular displacement pick-off which is built into the transmitter housing. A pointer mounted on the rotor shaft traverses a scale arranged on the front of the transmitter housing, thus providing a reading of the actual pressure obtaining at the point of measurement.

The input of the transistor switching device (Fig. 2) is a single-phase a.c. bridge circuit (demodulator) in which the input signal, i.e., the output signal of the pressure transmitter, is compared as to amplitude and phase with an adjustable reference voltage (Fig. 3). The difference in voltage produced on deviations from the set limiting value is phase-sensitive rectified in the demodulator and passed to the two-stage transistor amplifier proper. If the actual value falls below or exceeds the set reference value, the flip-flop circuit in the second stage of the transistor amplifier switches a relay with a reed contact.

Signal, alarm and safety devices can then be operated via the output of the relay, the method of evaluating the output signal varying according to the particular application. A further reed-contact relay is continuously energized by the power supply transformer of the monitor and on failure of the supply voltage closes a contact with which an alarm signal can be operated. The circuitry of the transistor switching unit is of the etched type.

The separate power supply unit, which can be supplied on special request, contains a gas-tight nickel-cadmium battery working in a floating arrangement with a transistor inverter. In the event of the mains voltage failing, the monitor can thus be supplied with power for a maximum period of 30 minutes. In the majority of cases the separate power supply unit can be dispensed with since the monitor is normally connected to the fail-safe bus or to the emergency power supply battery.

The smallest measuring range of the pressure monitor is 0 to 1 kg/cm² gauge (0 to 14.22 psig) and the largest 0 to 400 kg/cm² gauge (0 to 5,690 psig). Pressure ranges between these are staged in accordance with German Industrial Standards DIN 16120. The set ref-



1 Inductive angular displacement transmitter
2 Demodulator input
3 Demodulator output
4 Reference-value setter with calibrated scale
5 Mains transformer

Fig. 3 Single-phase a.c. bridge circuit with phase-sensitive rectification (demodulator)

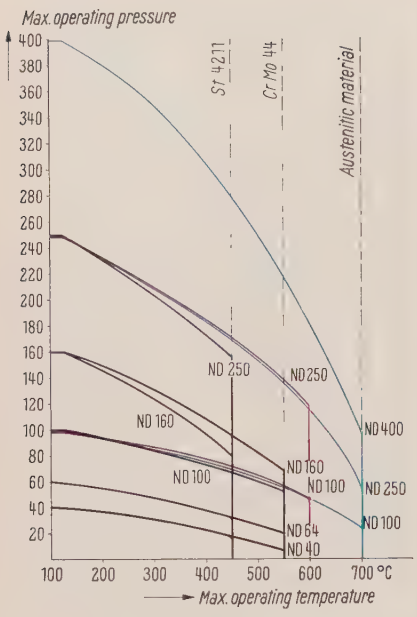
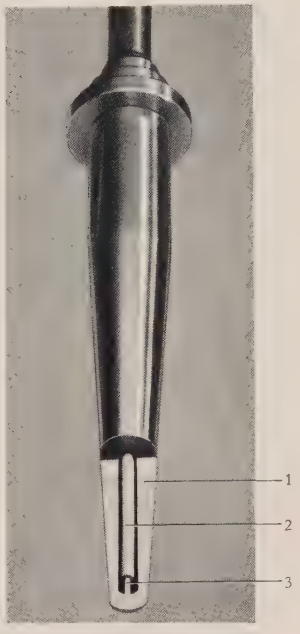


Fig. 4 Ranges of application of the various types of thermal transmitters (ND figures refer to the max. oper. pressure in kg/cm² of the particular model)



1 Austenitic outer element
2 Insulation
3 Solid constantan rod, pressure-proof

Fig. 5 Sectional view of the immersed part of a thermal transmitter

erence value is marked on the scale of the pressure transmitter, the exact value being adjusted on a special reference-value setter. This device which is provided with a calibrated scale is built into the transistor switching unit and permits the reference value to be adjusted by ± 5% within the measuring range of the transmitter.
The pressure monitor operates with an accuracy of 0.1% of the transmitter measuring range; with fluctuations in the supply voltage of between + 10 and – 20% the response accuracy is approximately 0.15%.

The difference between the pick-up and drop-off values of the monitor is approximately 0.5% of the end value of the scale.

For a.c. the switching capacity of the reed contacts is 55 VA at a maximum of 250 V or 0.3 A while for d.c. it is 15 W at a maximum of 60 V or 0.3 A. The power consumption of the monitor is 50 VA. The housing is a P 43 type of enclosure as defined in German Industrial Standards providing protection against contact with implements of all kinds, harmful dust deposits in the interior and against water surges from all directions. The maximum permissible ambient temperature is 45 °C.

The pressure monitor can be provided with either a maximum or minimum pressure contact.

Temperature monitor ZR-WT

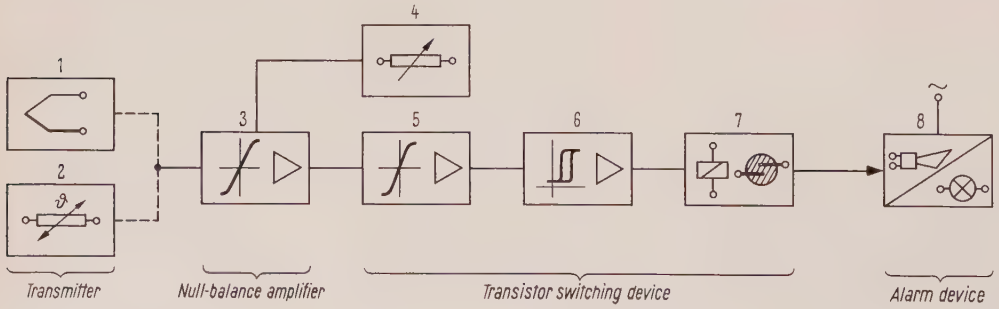
In the temperature monitor ZR-WT the measured value is converted into a thermo-electromotive force by a thermo-element. This thermo-electromotive force is compared with an adjustable reference voltage in a magnetic d.c. amplifier operating in a push-pull arrangement (null-balance amplifier), the resulting difference being amplified.

The thermo-element or transmitter can be supplied for screwing in, welding in or flanging on (Fig. 4). Since the outer element of the thermo-couple is of austenitic material and is of conical shape it can be built into the pipe without a protective sleeve (Fig. 5). With a half-time in water of approximately 1.4 to 1.8 seconds the detector is able to follow rapidly changing temperatures almost instantaneously.

The transistor switching device with the two-stage transistor amplifier is similar in construction to that employed with the pressure monitor. Here, however, the demodulator is omitted since the preamplified input signal is already in the form of a d.c. voltage (Fig. 6). In the case of temperature monitors, too, a separate power supply unit can be provided to cover the event of the mains supply failing.

It is also possible to use a resistance thermometer in place of the thermo-element, particularly for temperature ranges below 100 °C.

The standard measuring ranges of the temperature monitors vary according to the type of transmitter employed. With thermo-elements they range from 100 °C to 700 °C,



1 Thermo-element
2 Resistance thermometer
} Alternatives
3 Null-balance amplifier
4 Reference-value setter with calibrated scale
5 Transistor input amplifier
6 Transistor snap-action amplifier
7 Reed-contact output
8 Alarm device

Fig. 6 Functional diagram of a temperature monitor

with platinum resistance thermometers from 0 °C to 550 °C and with nickel resistance thermometers from 0 to 180 °C.

The operating value is set on the reference-value setter with a calibrated scale built into the transistor switching device.

With thermo-element transmitters, the operating accuracy of the monitors is 2 °C, with platinum resistance thermometers 1 °C, and with nickel resistors 0.5 °C, the difference between opening and closing being 2 °C.

The reed contacts have the same switching capacity as those for the pressure monitor and the type of enclosure and permissible ambient temperature are also the same. The power consumption of the temperature monitor is approximately 70 VA. The monitor can be supplied with either a maximum or minimum temperature contact.

Liquid-level monitor ZR-WN

The liquid-level monitor ZR-WN for the supervision of liquid levels is designed for flanging onto tanks or pipes (Fig. 7). The robust housing consists of tubular and wrought material. When the limiting value, fixed by the height at which the monitor is installed, is exceeded, the position of the ball float which projects into the connecting gland is changed, this movement being transmitted via a balance beam to a magnetic system. Through a non-magnetic pressure-proof partition the magnetic system acts on the actual switching device (Fig. 8).

The switch is operated, without making mechanical contact, by a permanent magnet which passes over the reed contact causing it to open or close under the effect of the magnetic field in accordance with the direction of movement of the magnet.

Any particles of iron in the liquid or any ferrous sludge are prevented from entering the magnetic system in the pressure chamber of the monitor by means of a magnetic trap.

For nominal pressures of 40 kg/cm² (568 psig), 64 kg/cm² (910 psig) and 160 kg/cm² (2,275 psig) the level monitors are provided with a standard DIN flange having a nominal internal diameter of 125 mm (4.92 in.). Fig. 9 shows the operating data for the various models. At the connecting flange the maximum permissible temperature is limited to 450 °C, this restriction being imposed by the properties of the materials.

The monitor has an operating accuracy of 3 mm in the level of the liquid, the difference between the opening and closing of the contacts being 10 mm. The switching capacity of the reed contact is the same as in the case of the pressure monitor.

A temperature-resistant connection is provided for the leads to the reed contact.

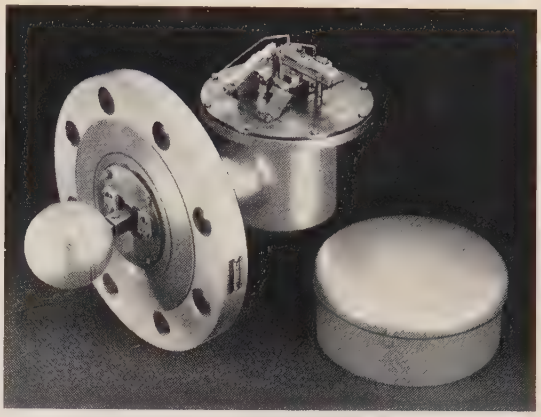
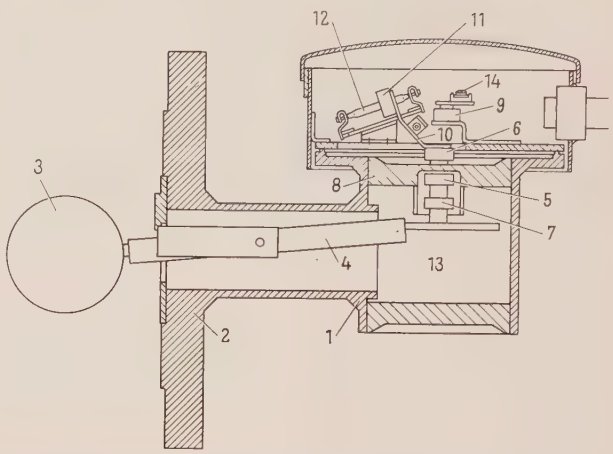


Fig. 7 Liquid-level monitor (cover removed)



1 Housing
2 Connecting flange (inside dia. 125 mm)
3 Ball float
4 Balance beam
5,6 Transmission magnet system
7 Magnetic trap
8 Pressure-proof non-magnetic partition
9 Resetting magnet
10 Rocker
11 Switching magnet
12 Reed contact
13 Pressure chamber
14 Terminal strip

Fig. 8 Schematic diagram of the liquid-level monitor

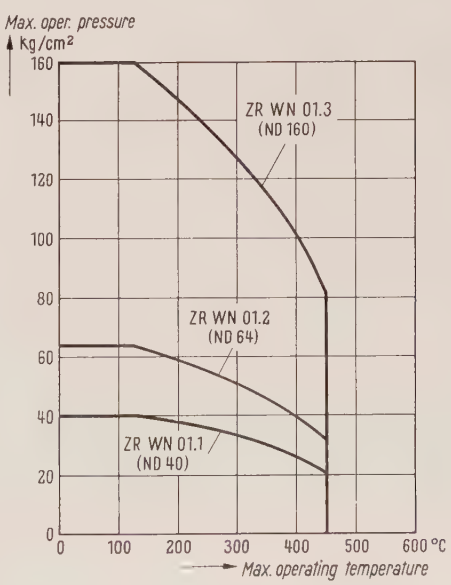


Fig. 9 Range of application of the liquid-level monitor (ND figures refer to the max. oper. pressure in kg/cm² of the particular model)

As is the case with the other monitors, the liquid-level monitors can be provided with a maximum or minimum level contact and where required, with a separate power supply unit.

No special maintenance is required for the monitoring equipment described.

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Level Control with the TELEPERM Z Controller

BY HANS NODER

With growing automation in power station operation electric controllers are rapidly gaining in importance. The modern trend is towards centralization of all regulating equipment in a control room or on an auxiliary board. The controlled conditions can be transmitted in a simple manner, thus making possible continuous supervision of the entire operation. Where mimic diagrams are used the indicating instruments for the operating data can be incorporated at the corresponding locations of the diagram. It is also possible to include in the mimic diagram signal indications of the mainly electrical supervisory devices, such as monitors for pressure, temperature and liquid levels [1].

The introduction of the electrical control of liquid levels was handicapped by the fact that the time taken by the conventional positioners to go through their complete range was not sufficiently short if at the same time discrete correction steps were required in order to achieve satisfactory control in the case of small control deviations. In the interests of operational reliability, it is desirable to use as positioners standard three-phase squirrel-cage induction motors which require no maintenance due to the absence of any parts subject to wear. The time required for the final control element to traverse its complete range at the maximum possible rate of change is therefore constant. In order to obtain satisfactory operating conditions, the time required by the liquid level regulating systems for going through the total valve lift range (full-scale traversing time) is as low as 15 seconds.

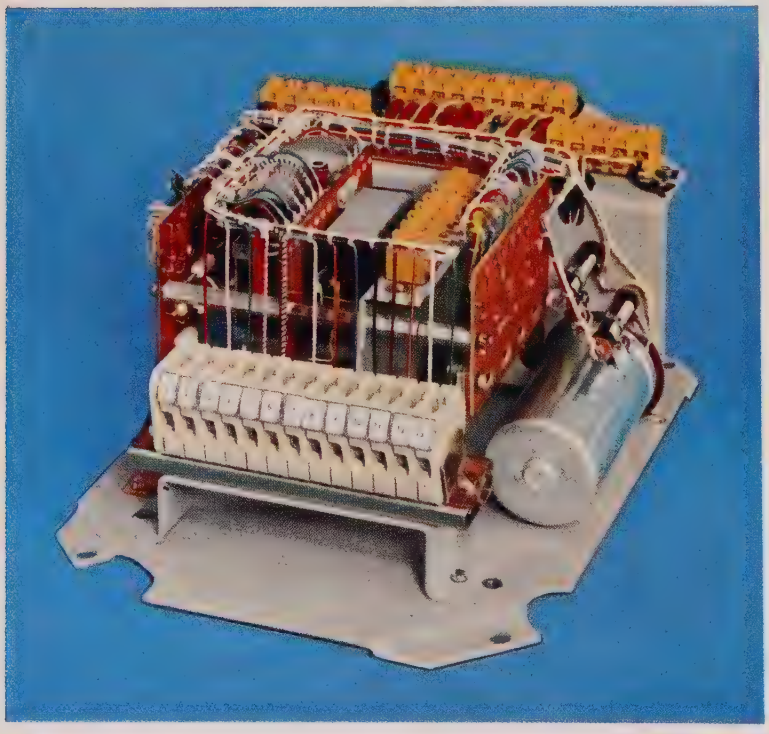


Fig. 1 TELEPERM Z automatic controller (Zeigerregler) mounted on a base plate

With the former electric controllers of the magnetic-amplifier or relay type, such short full-scale traversing times could not be achieved owing to the relatively long inherent time constants of the amplifiers. The minimum permissible impulse duration was approx. 0.2 to 0.4 seconds. With the advent of operationally dependable transistors the field of application of the electric controller in liquid level control was considerably extended. The switching time of the transistors is negli-

gibly short as compared with the inherent operating times of relays and contactors.

The new Teleperm* Z amplifier controller (Zeigerregler) meets the above requirements by the use of switching-transistor amplifier stages in conjunction with a capacitive feedback (Fig. 1). This is a three-state amplifier which has a separate switching stage for each switching direction. Each stage consists of two transistors. The switching function is achieved by reducing the base current of the first transistor via a potential divider arranged in the output circuit of the second transistor (feedback). Connected in the output circuit of the second transistor is a reed-contact relay which controls the respective power contactor of the positioning motor and the capacitive feedback. The sensitivity of response of the transistor switch stage is approx. 0.2 mA [2]. The transistor amplifier stages are only suitable for d.c. input signals. For a.c. input signals a series-connected demodulator is required.

The liquid level is measured in a separate vessel (Fig. 2). The movement of a ball float is transmitted via a magnetic coupling, without stuffing box, to an angular displacement control transmitter. A partition of non-magnetic material completely seals off the pressure chamber. The measuring range of the control transmitter is ± 80 mm. The control transmitter operates on the same principle as a single-phase a.c. induction regulator and its output voltage of ± 10 V remains within the practically linear range of the transmitter. The shaft of the control transmitter carries a pointer so that the movement of the pivoted ball float can be read on an external scale.

Owing to the integral action inherent in the controlled system, the level controller is designed as a proportional-action controller (Fig. 3). The valve lift is directly proportional over its total range to the control transmitter position. Electrically the control (level) transmitter and the position transmitter mounted on the valve positioner are connected in anti-phase. The differential voltage is fed as control deviation to a demodulator, a phase-sensitive rectifier, which feeds this voltage as d.c. error signal to the controller.

As already mentioned, it is necessary to keep the undesired overtravel of the gear to a minimum in the case of short full-scale traversing times. In this connection capacitive braking circuits have proved very effective. A capacitor connected across two phases of the positioning motor is charged via a rectifier during the impulse duration. After dropping out of the control contactors this capacitor discharges via the motor winding, thus producing a strong braking torque. With optimum charge-up voltage and capacitor rating, the braking effect obtained will bring the motor to standstill within 1 or 2 revolutions.

The characteristic factor of a liquid level control system is a measure for the speed with which the level controller

* Trade-mark

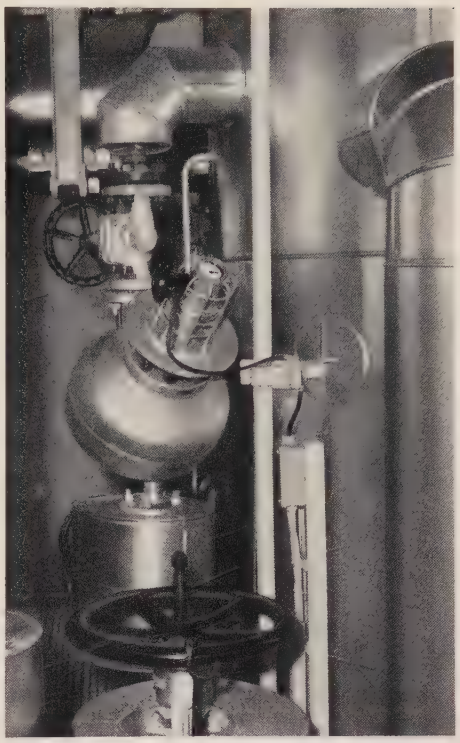


Fig. 2
Liquid level transmitter with inductive pick-off

traverses the measuring range on a 100% load change

$$v_{max} = 2.12 \frac{Q}{d^2}, \quad \text{or} \quad v_{max} = 1.66 \frac{Q}{F}$$

where

v_{max} is the maximum rate of change, in cm/min, at a 100% disturbance

Q is the maximum rate of flow through the vessel, in tons/hr

d is the diameter of the vessel, in metres, within the measuring range

F is the cross-sectional area of the vessel, in m², at normal liquid level

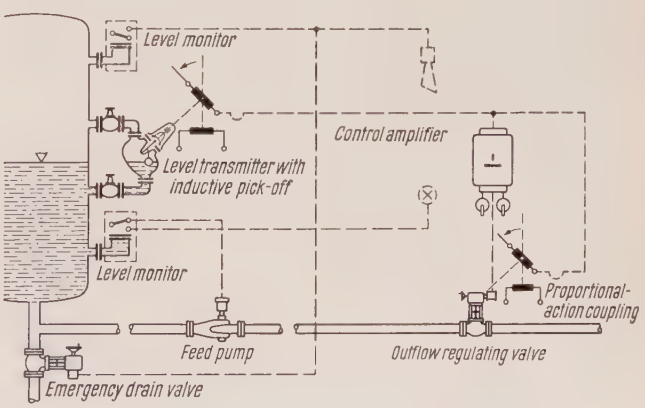


Fig. 3 Schematic representation of a liquid level control system

At a 100 % disturbance, a measuring range of 160 mm results for the control transmitter in a full-scale traversing time of

$$t_{m100} = \frac{960}{v_{max}}$$

where

t_m time taken for traversing the measuring range, in seconds

t_{m100} time taken for traversing the measuring range at a 100 % disturbance

t_{mx} time taken for traversing the measuring range at a disturbance of x % full load

h_m measuring range of the transmitter, in cm

At a disturbance of x % full-load the full-scale traversing time at the maximum rate of change is

$$t_{mx} = t_{m100} \frac{100}{x}$$

Experience with liquid level controls under normal operating conditions has shown that it will suffice to assume a sudden load change of 10 % of full load when designing the control system. This also takes into account the fact that large disturbances always occur within a definite time period since the water and the steam circuit of a thermal power plant have their own time constants. In general, it can be said that disturbances will be controlled out by the controller without giving rise to greater control deviations if the full-stroke operating time of the valve is so selected that the flow through the valve changes with the magnitude of the disturbance. This assures that the measuring range available can as far as possible be fully utilized as proportional range. The proportional range X_p required for level control depends on the overall full-scale traversing time T_y of the valve positioner and the maximum rate of change of the controlled condition assuming a sudden disturbance of 10 % full load. This results in a proportional range

$$X_p = 0.1 \frac{v_{max}}{60} \frac{T_y}{2}$$

In most cases, however, the proportional range available will be larger than the measuring range required. In order to provide the best possible damping of the control action, the controller is fitted with a capacitive feedback which permits optimum matching to the particular controlled system. The capacitive feedback can also be used to compensate the effects of the time lag in the measurements of the level transmitter and the overtravel of the gear.

For the design of level control systems (Fig. 4) the following therefore applies:

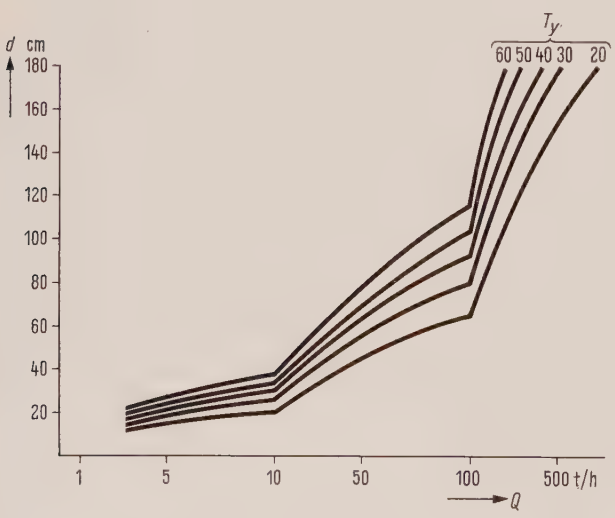
$$d = 0.015 \sqrt{Q}\, T_y, \text{ or}$$

$$T_y = 4500 \frac{d^2}{Q}$$

In the planning of control systems, particular importance should be attached to the design of the valves. From the above it can be seen that the valve should be given a linear characteristic, i.e., the rate of flow through the valve should vary in proportion to the valve lift. In the case of regenerative feed heating plants, account has to be taken of the differential pressures varying with the load and, if pumps are provided, the pump performance characteristics have also to be taken into consideration. Highly disadvantageous for the control quality are oversized valve seats since these shorten the total operating range of the positioning element. A safety margin of approximately 25% is generally adequate. The backlash of the positioners should be kept to a minimum, particularly that of the mechanical coupling of the inductive transmitter indicating the valve position.

A few of the new electric TELEPERM Z liquid level controllers have been in operation for some time in industrial installations and have proved very satisfactorily. In the applications in question a high maximum rate of change v_{max} under particularly arduous conditions is required.

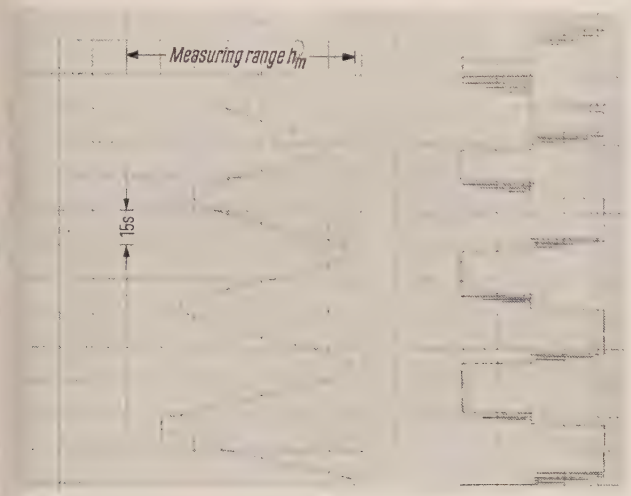
The control system described below was built for a horizontal high-pressure feed heater with a maximum rate of flow of 24.8 tons/hr. The water level is maintained in a collecting vessel of 35 cm diameter. This results in a maximum rate of change of v_{max} = 430 cm/min. The measuring range of 16 cm is traversed in 2.2 seconds and the valve positioning time on a full-scale step change is T_y = 22 seconds. This was achieved by selecting a valve with an adequate lift. The plant appeared particularly suitable for trial purposes since, at a low turbine load, the condensate is drained to the next lower feed heater, but above a definite load to the feedwater tank. The changeover is controlled by a contact-making pressure gauge dependent on the extraction steam pressure in such a manner that the controller is caused to change over from



Q Rate of flow d Diameter of vessel T_y Full-scale traversing time

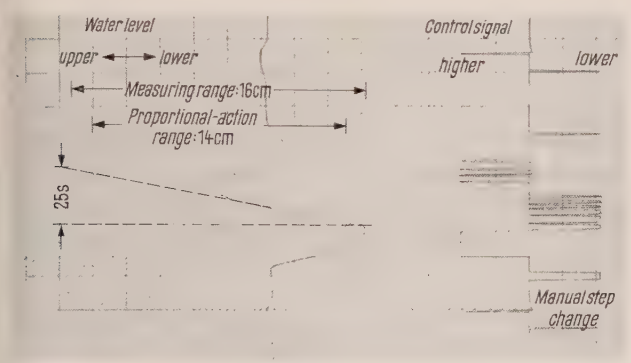
Fig. 4 Design data for liquid level control systems

one valve to the other and the first valve is closed. On account of the excellent control properties of the Teleperm Z automatic controller, it was in this case possible to keep the transient deviation caused by the changeover to a minimum.



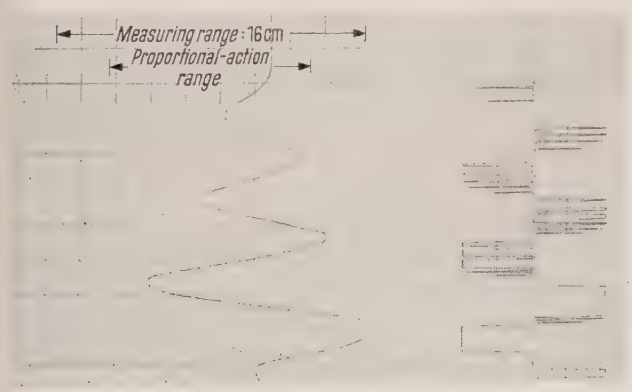
Q = 24.8 t/h d = 0.35 m T_y = 40 s X_p = 75 %

Fig. 5 Control action following a step change of 10% full load



Q = 24.8 t/h d = 0.35 m T_y = 22 s X_p = 100 %

Fig. 6 Control action following a step change of 10% full load



Q = 24.8 t/h d = 0.35 m T_y = 22 s X_p = 75 %

Fig. 7 Control action following a step change of 10% full load

The resulting measurements obtained on testing this control system are best illustrated by a few records. In each case the water level within the measuring range of the transmitter and the control impulses from the controller were recorded. Fig. 5 shows the control action following a disturbance initiated by hand for a full-scale traversing time of approximately 40 seconds. It can be seen that the transient is only slightly damped and that the time taken to line up with the command impulse is rather long. From the steepness of the first overshoot the time taken for traversing the measuring range is 25 seconds. This corresponds approximately to a step change of 10% full load.

Fig. 6 shows the same control process for the same disturbance but with a valve positioning time on a full-scale step change of approximately 22 seconds. The disturbance is practically controlled out after one overshoot. This record also shows the relatively small subsequent overshoots and the high sensitivity of the controller. The extent to which the proportional range affects the quality of control can be seen from Fig. 7. A reduction of the proportional range to 75% resulted in a 300% increase of the settling time. This record also shows clearly the precision of the sequence and duration of the pulses dependent on the change in the control deviation. The conventional controllers of the relay or magnetic-amplifier type did not permit such differentiated contact making.

In order to take full advantage of this feature with respect to the control quality, great importance must naturally be attached to the control of the overtravel of the gearing. The overtravel period of the gear of this installation, with the capacitive braking circuit effective, averaged 1.2 revolutions of the motor positioner shaft. This corresponds approximately to 25% of the shortest impulse duration of 0.1 seconds and can be considered as reasonable for very short full-scale traversing times.

In conclusion it can be said that the new Teleperm Z automatic controller completes the line of Siemens controllers. The field of application for the electric controllers can now be considerably extended, particularly in the heat-producing and heat-consuming industries. The new controller which is of simple design and therefore inexpensive can also be used to solve other control problems requiring short full-scale traversing times, e.g. longitudinal register and loop controls. With respect to its components, such as reed-contact relays and amplifier stages with etched circuitry protected by a synthetic resin coating, it reflects the latest advances in engineering development.

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New D.C. Locomotives for Double-unit Operation in Open-cast Lignite Mines

By Wilhelm Wüste

At the beginning of 1960, five d.c. Bo-Bo locomotives with a gauge of 900 mm (3 ft.) and a weight in working order of 65 tons were put into service at the mines of the Braunschweigische Kohlenbergwerke Helmstedt. In each case, two locomotives are coupled to form a double unit, the fifth locomotive serving as a standby. The mechanical part of the locomotives was built by Krauss-Maffei AG, München-Allach, and the electrical equipment supplied by Siemens-Schuckertwerke. Below is a brief description of the new features which have been incorporated in these locomotives.

Mechanical part

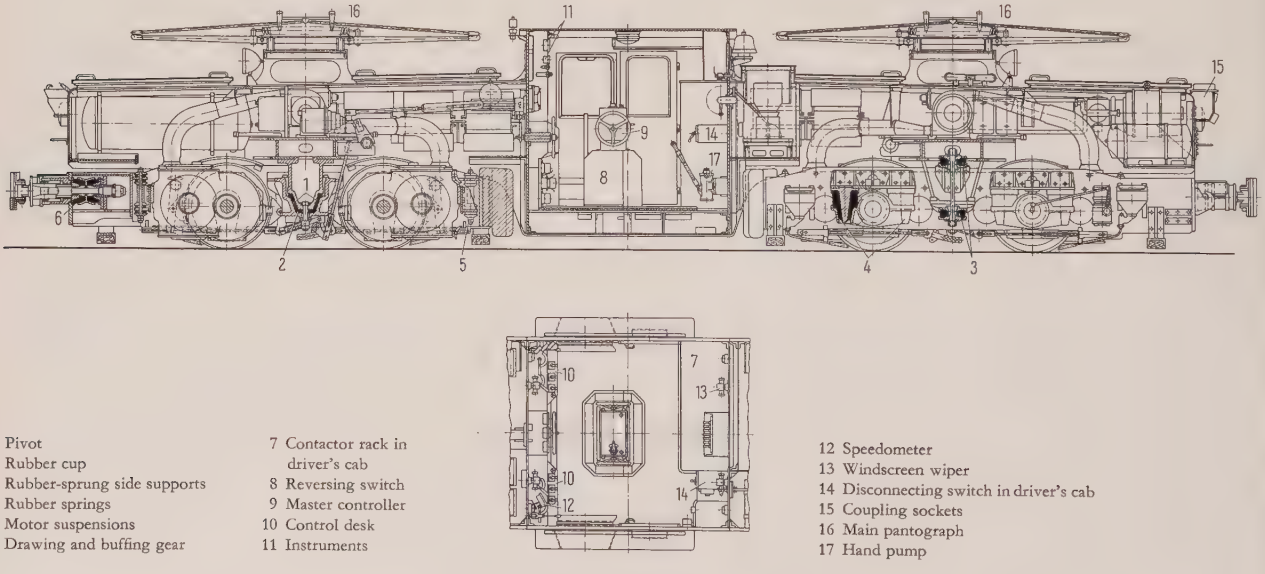
The requirement that two bogie locomotives be coupled together to form a unit was the outcome of many years of observation during operation. From the standpoint of ability to negotiate curves and to operate on distorted movable tracks, this arrangement is better than one employing short-link articulated frames with axles running rigidly in these. The new arrangement also reduces appreciably the wear and tear on tires and track. Special importance was attached to the use of non-wearing rubber elements in place of normal springs.

The superstructure of the four-axle bogie locomotive (Fig. 1) is supported on two pivots (1) on two bogies. In the former arrangement the ball formed at the bottom end of the pivots was seated in a spherical cup on the bogie. Properly lubricated, this permitted the bogies to move freely on curves and on unlevel track. The lower part of the hollow pivot employed on the new locomotives has the form of a truncated cone which rests in a rubber cup (2) seated in a bogie bearing of the same shape. This and the rubber sprung supports at the side (3) provide the bogies with freedom of movement and enable them to follow all irregularities of the track. Most of the energy produced by impacts is converted into deformation of the rubber, the small remainder being transmitted to the superstructure.

The steel suspension springs between the bogie frames and wheel sets, usually employed on bogie locomotives of this type, have been replaced by rubber springs (4) which also act as wheel guides in the longitudinal and cross direction. As a result of the interaction of the rubber pivot bearings, the rubber-sprung side supports and the wheel sets, the new locomotives operate much more quietly than is the case with the older models.

To reduce the wear on the motors and gears and to eliminate the effects of hard impacts during shunting operations, the motor suspensions (5) and the drawing and buffing gear (6) have likewise been provided with rubber springs.

The drawing gear is designed for the tractive effort of two locomotives. The rubber springs and guides are of the non-wearing type and no maintenance or lubrication



1 Pivot
2 Rubber cup
3 Rubber-sprung side supports
4 Rubber springs
5 Motor suspensions
6 Drawing and buffing gear
7 Contactor rack in driver's cab
8 Reversing switch
9 Master controller
10 Control desk
11 Instruments
12 Speedometer
13 Windscreen wiper
14 Disconnecting switch in driver's cab
15 Coupling sockets
16 Main pantograph
17 Hand pump

Fig. 1 Construction of the d.c. locomotive for double-unit operation

is required. Spring breakages etc. which are a source of trouble with the conventional type of locomotive, are thus obviated.

Electrical part

In the specifications for the locomotives, the requirement was made that electro-pneumatic contactor control be employed and that it be possible to drive the locomotive from either the leading or trailing locomotive.

The contactors for the starting and braking system of the traction motors in series-parallel and parallel connection are arranged on a sheet-steel enclosed contactor rack (7) in the driver's cab and are thus easily accessible for maintenance. The reversing switch (8) is located in the centre of the driver's cab. Arranged above this is the master controller (9) for the 24-V electro-pneumatic control of the running and braking contactors; for the first time this has been positioned horizontally with two hand wheels at the side (see Fig. 2). Located on a control desk (10) on the end wall of the driver's cab are the operating levers for the brake valve, auxiliary valve, whistle, bell, sander and pantograph. From his position, the driver is quite easily able to operate all of these.

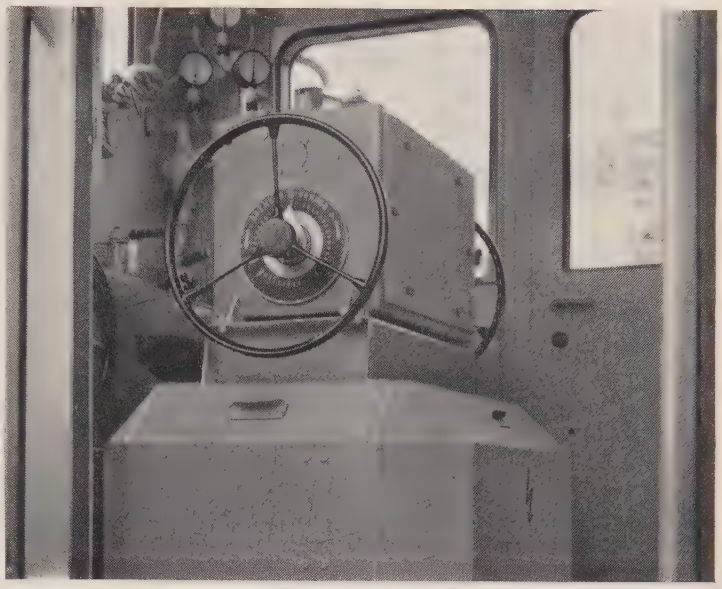


Fig. 2 Reversing switch and master controller for the running and braking contactors

Added to these are easily readable instruments (11), speedometer (12) and a pneumatic windscreen wiper (13).

The control cables to the second locomotive are run via a disconnecting switch (14) in the driver's cab and coupling sockets (15) and plugs on the end wall of the locomotive. In the event of a motor failing, the control system of the defective locomotive is isolated by the disconnecting switch (14). The locomotive can then be towed away and replaced by the standby.

The main pantographs (16) are operated electro-pneumatically. A hand pump (17), which can be connected to the air pipe of the pantographs via a three-way valve, is provided for raising the pantographs when the air receiver is empty. The auxiliary pantographs of the locomotives are mechanically operated by means of cables. In double-unit operation, however, this method is inconvenient on the trailing locomotive. For this reason, a power coupler is provided between the ends of the two locomotives for the supply of power to the trailing locomotive during stope haulage. A further cable coupler serves to supply power to the signalling device and the lighting at the end of the train.

Technical data

Each locomotive is equipped with four nose-suspended traction motors having the following data:

One-hour rating	190 kW with separate ventilation
Rated d.c. voltage	1,200 V
Speed at one-hour rating	800 r.p.m.
Maximum speed	1,750 r.p.m.
Gear ratio	94 : 14 = 6.71

With a wheel diameter of 950 mm (37 1/2 in.) (new) and at a one-hour rating as defined by the specifications of the Association of German Electrical Engineers VDE 0535, the double unit develops a tractive effort of 25,600 kg (56,300 lbs.). The speed at the onehour rating of the locomotive is 13 miles per hour and the maximum speed is 28 miles per hour. Fig. 3 shows the characteristics for these locomotives in double-unit operation.

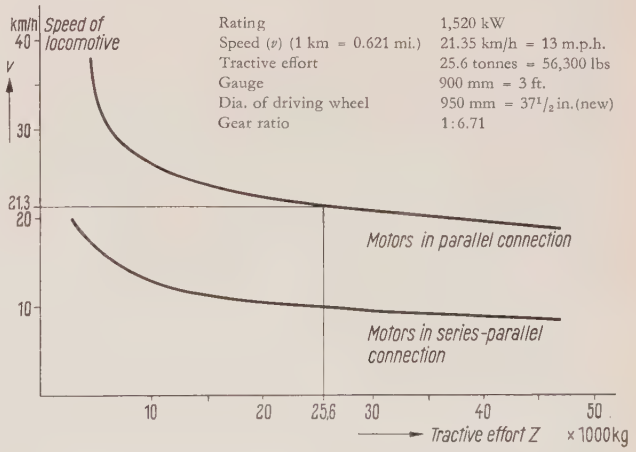


Fig. 3 Characteristics for two 65-ton locomotives in double-unit operation

Siemens Kabelwerk

By Heinz Kücken

Cables and wires are indispensable for the functioning of all electrical installations.

The early pioneer work of Werner Siemens in the field of communications engineering marks the start of the cable manufacturing activities of the House of Siemens. As far back as 1848 the first German telegraph lines were erected by the Telegraph Factory which he founded with Johann Georg Halske in 1847. The demand for telegraph lines was, however, much greater in England than in Germany and the first Siemens & Halske Cable Works was commissioned in 1863 in Charlton near London.

As early as 1866, however, a Siemens Cable Works was also erected in Germany, namely in Berlin. In 1912, cable manufacture was moved to the new factory in Berlin-Gartenfeld.

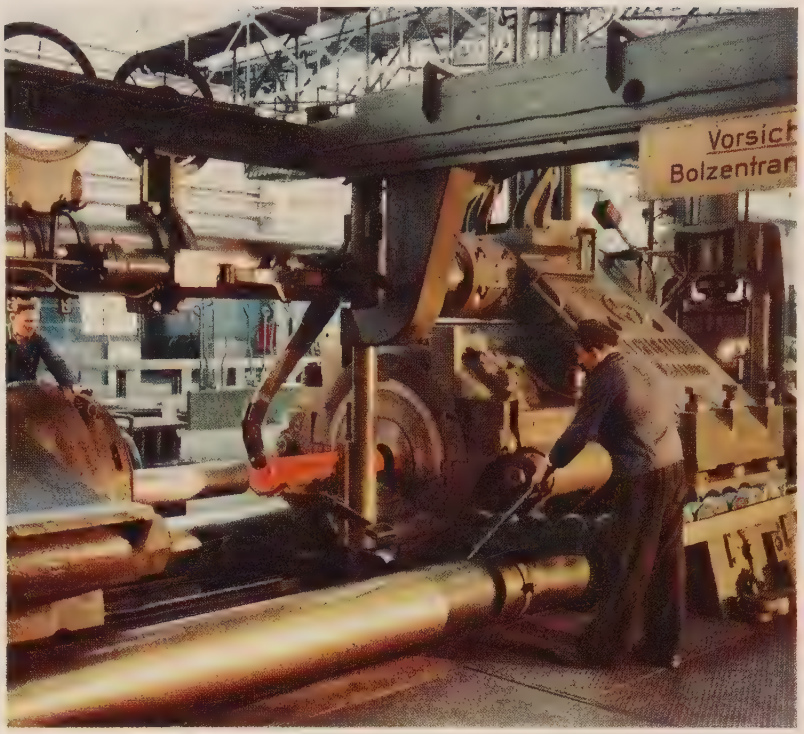
In 1917 the Kabelwerk was extended to include a Metal Smelting and Processing Plant (Metallwerk) which supplies the necessary semi-finished metal products. The copper and copper-alloy blanks for special applications are produced in the works' own smelting shop. The copper is refined in modern drum-type furnaces and then cast as round billets. Semi-finished products for bars, tapes and wires are produced from preheated billets on extrusion presses by hot-working. In the following rolling, drawing and annealing processes the semi-finished products are given their final dimensions and special properties. Wire of all necessary dimensions and grades is produced on modern wire drawing machines. In one section of the plant it is possible to draw, anneal and coil the wire in one continuous operation.

The Kabelwerk manufactures power cables for all voltages, heavy-duty tough-rubber-sheathed cables for underground mines, outdoor communications cables for local, regional and long-distance service, radio-frequency transmitter and receiver cables, fittings for all cable types manufactured and enamelled and dynamo wires.

The first step in actual cable manufacture is the insulating of the conductors. These are lapped with either paper or plastic tape or provided with plastic sheaths in special screw extruders. The conductors of power cables with

Fig. 1 Approximately 3,700 persons are employed in the Kabel- und Metallwerk in Berlin-Gartenfeld. The factory premises cover an area of 342,000 m². The actual built-up area is 123,000 m².

Fig. 2 A 2,400-ton extruder in the Metal Smelting and Processing Plant (Metallwerk). In this machine the preheated round billets of light or heavy alloys are pressed through dies to form bars, tapes and wires. In the following drawing, rolling and annealing operations these blanks are further processed to semi-finished products of very high quality



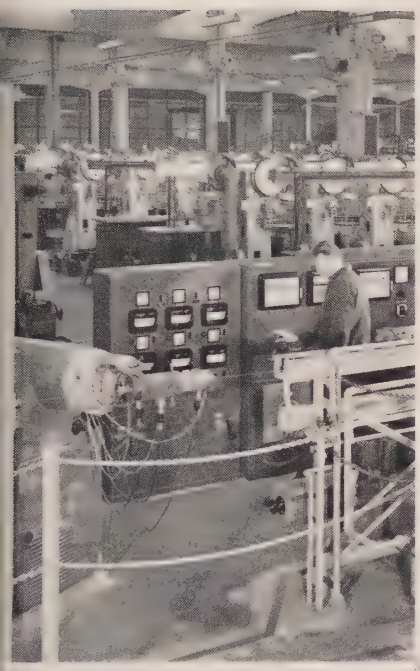


Fig. 3 The manufacture of cores for communications cables. The copper conductors are insulated with cords and tapes of paper or plastic on lapping machines. PVC or polyethylene compounds are extruded over the copper conductor in screw extruders. In the screw extruder plants cables are manufactured in one continuous operation from the uncoiling of the copper conductor to the coiling-up of the insulated cores on drums. Numerous instruments are used for measuring, regulating and recording purposes. The major electrical characteristic values of the insulated cores are also measured and recorded

Fig. 4 In these large cabling machines four cores are twisted together to form the unit group of cables for communication lines. Cables of both the layer and multiple-unit type can be constructed. The machine for layer-type cores (left in illustration) has 4 cabling baskets. With the aid of change gears, the axial length and direction of the twist can be changed for the various layers. In one pass through the machine up to 216 unit groups can be laid up together

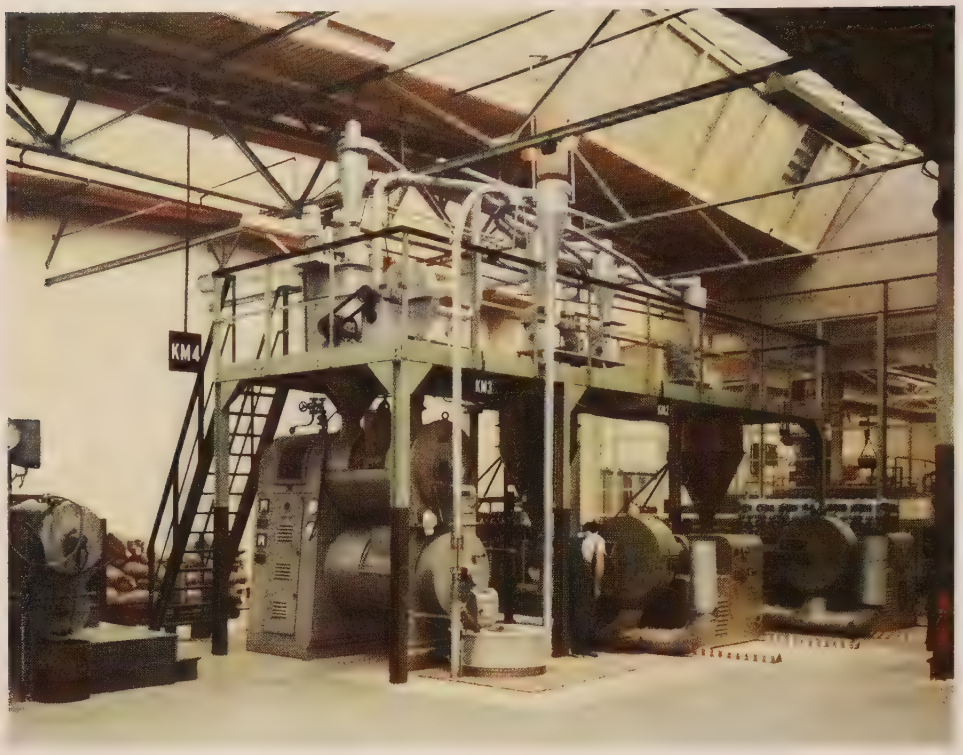


Fig. 5 In the plastic mixing plant. Thermoplastics have found extensive application as insulating materials in the cable industry. In order to achieve particularly high mechanical and electrical qualities, various plastics are mixed with each other according to the works' own formulas and processed in a special mixing and gelling machine. The material is transported by pneumatic conveyors in the continuous process plant. The mixtures are further processed in screw extruders to core insulation or cable sheaths. Plastic-sheathed cables have already been supplied with outside diameters of up to 180 mm

large cross-sections are manufactured as stranded round, sector-type or hollow conductors with the insulation being applied in the same process. The insulated conductors, called cores, are then laid up together in large cabling machines and once more insulated. In order to obtain an optimum dielectric strength, paper-insulated cable cores are dried under vacuum in heated chambers or vessels. To accelerate this process, the conductors themselves are heated by electric current. After drying, paper-insulated power cables are treated with resinous impregnating compounds or insulating oil. A seamless lead or aluminium sheath is then extruded over the

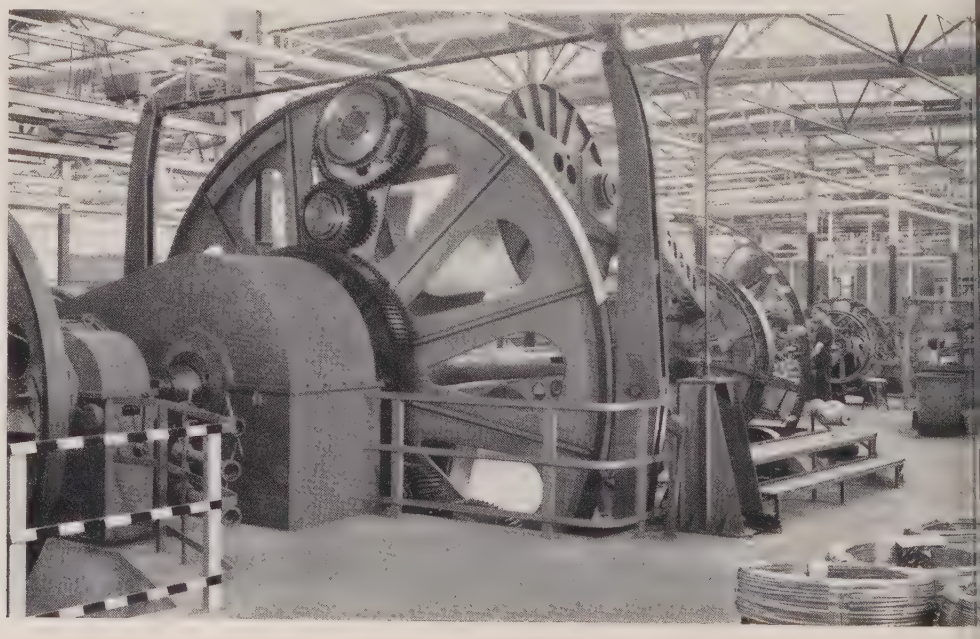


Fig. 6 Plastic or paper-insulated cores for power cables are laid up in a four-head cabling machine. The large cabling machine illustrated can take drums with a flange diameter of 2.4 metres and a maximum total weight of 15 tons. Reduction gears permit constant pay-off of the cores so that no torsion is introduced when laying up the cores

Fig. 7 In order to obtain a high dielectric strength, the paper lappings of the cores must be dried under vacuum in special vessels and treated with impregnating compound. The required operating conditions in the vessels and the electrical quality of the cable insulation are constantly measured and recorded during the drying and impregnating process

Fig. 8 Loading 300-kV oil-filled cables in the stock yard of the Kabelwerk for transportation by ship to Norway

cores. In the following processes the cable sheaths are wrapped with plastic, steel tape or wire armouring with intermediate layers of impregnated paper or jute and provided with anti-corrosion coatings.

In recent years extensive use has been made of special plastics as insulation and protective sheaths for power and communications cables. These plastics have excellent mechanical and electrical properties and are easy to work. The material is converted to a state of plastic flow by heat and pressure in screw extruders and shaped to insulating jackets and cable sheaths by suitable dies in continuous processes.

All the products of the Kabelwerk are subjected to exhaustive tests before being supplied to the Customer. Numerous laboratories and large well-equipped testing stations make it possible to continue further technical development and guarantee the quality of the products which are renowned the World over.

NEW EQUIPMENT

Stage-lighting Equipment for the Passion Play Theatres in Austria

BY WILHELM FOHLER

In Austria at present there are three well-known Passion Play theatres, one in Lower Austria (Kirchschlag) and two in Tyrol (Erl and Thiersee).

In place of the former small Passion Play hall in Kirchschlag a substantially larger Passion Play theatre more in keeping with the modern requirements of our time was built and opened in May 1959. This theatre has seating for 1,200, is air-conditioned and is among the most modern of its kind.

The lighting control equipment for the stage with forestage is accommodated in a control room which is located above the ceiling of the auditorium and stretches over the entire width of the latter. In addition to the apparatus for the forestage lighting the control room also contains the stage dimmer control board with the regulating transformers and the stage switchboard.

A double-row Siemens-Schuckert stage dimmer control board with a total of 24 control lever units is used for controlling the stage lighting. The control circuits are fed from three Siemens-Schuckert single-phase Bordoni-type regulating transformers each with a rating of 18 kVA.

The stage has no adjustable proscenium, no curtains and no fly floor but has an arched cyclorama projecting over the entire depth of the stage into the auditorium. The cyclorama is provided with a fluorescent coating and is illuminated by ultra-violet floodlights and Siemens-Schuckert footlights. Small lights with low-voltage lamps built into the masonry of the arched cyclorama give the impression of a starry sky. Siemens-Schuckert 1,000-W, 24-V specular-reflector stage spotlights and various Siemens-Schuckert lens-equipped spotlights provide the illumination for the forestage.

The lighting installation is also supplemented by a few lighting devices located on the stage and hidden by the permanent stage scenery.

The Passion Play theatre in Erl was opened in June 1959. It has a large stage and seating for 1,500.

The stage lighting equipment consists of a stage lighting control installation with 48 separately controllable circuits. For the brightness control six Siemens-Schuckert Bordoni-type regulating transformers were installed (Fig. 1) whose current collectors are controlled from a Siemens-Schuckert double-row stage dimmer control board (Fig. 2).

The stage lighting is provided by a large number of Siemens-Schuckert 1,000-W, 24-V specular-reflector spotlights located in the proscenium. In the adjustable proscenium area and on the lighting gallery further Siemens-Schuckert spotlights for 500 and 1,000 W and various stage effects apparatus and projectors are mounted.

The new Passion Play theatre in Thiersee was opened in May 1955 and has an auditorium with seating for 935.

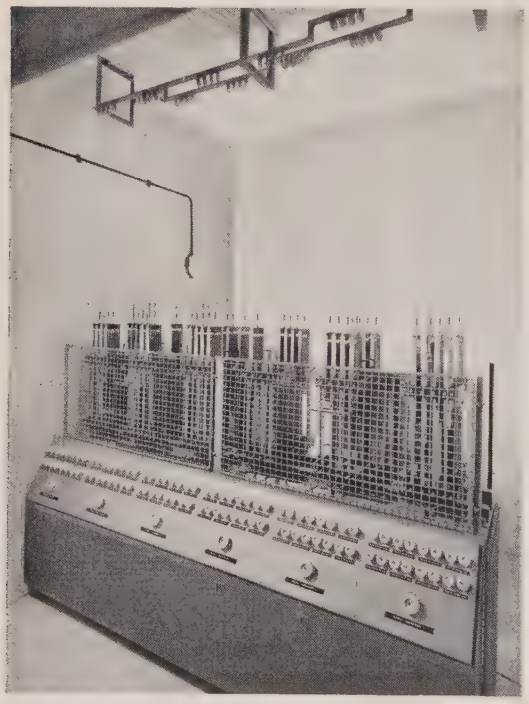


Fig. 1 Stage-lighting regulating transformer in the Passion Play theatre in Erl (Tyrol)

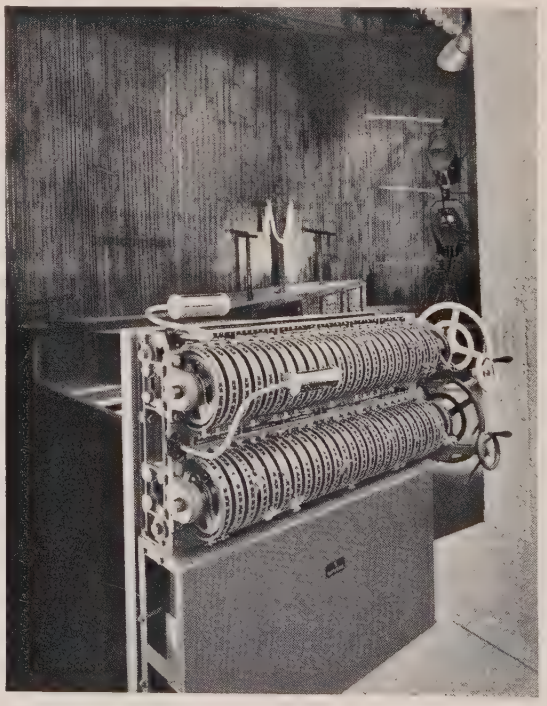


Fig. 2 Control station with stage dimmer control board in the Passion Play theatre in Erl (Tyrol)

For the stage lighting a triple-row Siemens-Schuckert stage dimmer control board with a total of 36 control levers was installed for controlling five Siemens-Schuckert Bordoni-type regulating transformers.

The cyclorama is illuminated by a special lighting installation with 24 Siemens-Schuckert cyclorama floodlights.

The remaining stage lighting is provided by Siemens-Schuckert specular-reflector spotlights for 1,000 W, 24 V and spotlights for 2,000 W, 220 V. Footlights, borderlights, spotlights with remote-controlled colour filter magazines, cloud simulating units and slide projectors for 5,000 W complete this modern stage lighting installation.

Communications Equipment of the Hotel am Zoo in Berlin

By Horst Mostler and Heinz Hoffmann

The internationally famous Hotel am Zoo is located on the Kurfürstendamm, right in the heart of downtown Berlin.

This luxurious hotel, which forms a vivid center of interest during the Berlin Film Festivals and many other important events and congresses, has been equipped with the most up-to-date communications systems designed to simplify hotel organization and give guests the best possible service.

Its large telephone systems, a luminous call system for summoning waiters, room maids and bell hops, a press-to-talk intercom system, a radio program relaying system, telex equipment, signaling systems, and the radio-operated staff locating system were supplied and installed by the Berlin branch of the Siemens & Halske AG, whose customer service has also assumed responsibility for its maintenance.

All telephone calls for guests are handled by a modernly designed hotel telephone system with four switchboard positions, 20 outside trunks and 200 extensions. The attractively styled ivory-colored telephones (Fig. 1) match the modern décor of the bedrooms.

A PABX is available for the telephone calls of the management. A press-to-talk intercom system permits rapid consultation between telephone switchboard operators and reception clerks.

Each bedroom is provided not only with a pushbutton panel for calling the waiter, room maid or bell hop over the conventional luminous call system (see Fig. 2), but also with a control console for radio program selection. Guests are able to select any of five different programs and adjust loudspeaker volume according to taste. At the request of the management, the loudspeakers were installed in the ceiling. The resulting diffusion of sound is greatly appreciated by radio listeners. The respective amplifiers, radio sets and control units are installed in a number of swinging-gate type frames in wall cabinets in the switchboard operators' room. Program voltage meters on a panel incorporated in one of the switchboard positions monitor the five radio programs, each of which can be checked aurally in turn over a loudspeaker assembly.

In normal circumstances guests in their bedrooms are able to select any of five local radio programs. It is, however, also possible for programs from phonograph records, magnetic tape or a microphone in the lounge to be relayed to bedrooms over this system.

The moment it was placed in service the new radio-operated staff locating system showed itself to be extremely effective in expediting the movements of hotel personnel. Personnel provided with miniature radio receivers (see Figs. 1, 2) remain accessible over this system at all times and in whatever part of the hotel they may

Fig. 1 Bedside telephone
The room maid has a receiver belonging to the radio-operated staff locating system in her apron pocket and can thus be reached by the management at any time

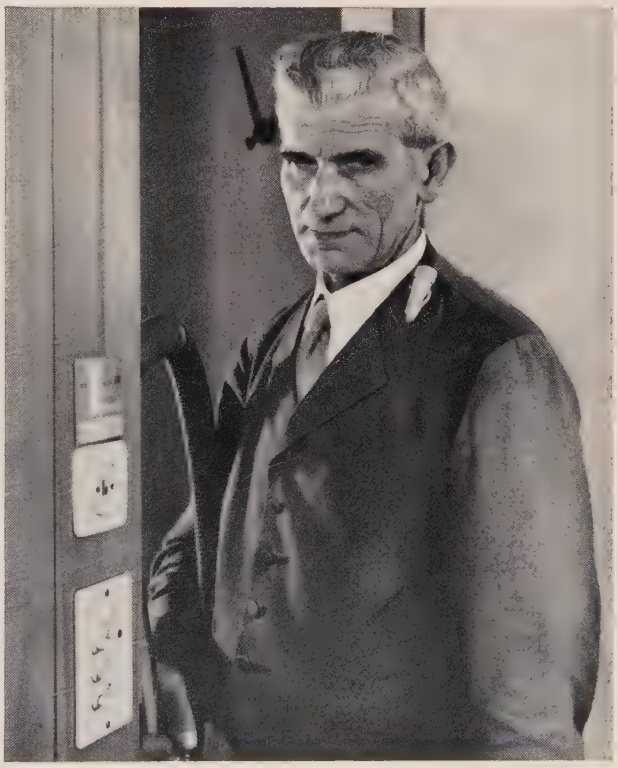


Fig. 2 The porter wears the miniature earphone of the staff locating system attached to his lapel.
Next to the door is the pushbutton panel of the luminous call system

Fig. 3 Calling station of radio-operated staff locating system

be. The calling station is provided with buttons for the various calling frequencies and a microphone for issuing instructions. It is to be found on the reception clerk's desk (Fig. 3). The system is additionally provided with an audio amplifier stage at which a number of wire loops terminate on appropriate transformers. These loops are installed in the ceiling of the corridor of every other floor. The amplifier power required for the entire hotel is 100 watts. In order to locate a wanted member of the staff the hotel porter presses the button assigned to this person, thereby causing the respective calling frequency to be transmitted for as long as the button is held down. The frequency is picked up only by the earphone of the receiver of the wanted person. Two different sequences of tones can be transmitted, one of which may mean, say, "Call the switchboard" while the other means "Switch on your receiver to receive a message". In the latter case the person called should press the button of his earphone, whereupon he will be able to listen to the message given through over the microphone. Manager, receptionist, room maids and porters all carry one of these small handy receivers on their person.

The radio-operated staff locating system is particularly useful in that it eliminates the considerable amount of time earlier wasted in locating hotel personnel. The hotel management plans later on to make similar receivers available on demand to guests so that they can be reached at any time in any part of the hotel premises.

Further facilities such as call systems for the kitchen, various signaling systems, luminous call panels in the receptionist's office, and a Siemens pageprinter complete the communications equipment of the Hotel am Zoo.

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SIEMENS

U.D.C. 621.317.087:658.5

ERNST WEBER

Data Reduction by Data Processing

3½ pages, 6 figures, bibliography

Siemens Review XXVIII (1961) pp. 137 to 140

The author discusses the advantages resulting from the use of digital measuring methods for data reduction problems.

SIEMENS

U.D.C. 621.317.087

HANS BREUNIG AND HANS KÜRNER

An Electronic Diagram Reader Facilitating the Evaluation of Charts

4½ pages, 5 figures

Siemens Review XXVIII (1961) pp. 140 to 145

Recording measuring instruments are used as indispensable expedients for plant management and for storing variable quantities by continuous measurements. The subsequent evaluation of the charts for the purpose of production control, planning, and statistics is very time consuming when carried out by hand. For reducing the evaluating costs, the Measuring Apparatus Division (Wernerwerk für Meßtechnik) of Siemens & Halske AG has developed an electronic diagram reader.
The curves are scanned with the aid of a television camera tube. Evaluation is effected digitally by means of counting methods. As a result, the area below the curve, the probably distribution or the probability density, and the amount of evaluated hours are numerically indicated.
A detailed description is given of the principle and construction of the diagram reader.

SIEMENS

U.D.C. 621.316.7 + 621-525

HERMANN BURKARD AND WILHELM NEUSE

A New Electropneumatic Potentiometer Controller

4 pages, 7 figures, 2 tables

Siemens Review XXVIII (1961) pp. 145 to 149

A report is given of a new electropneumatic controller which is designed to replace the former types of electropneumatic controllers. The entire pneumatic circuit arrangement is accommodated in the base plate, to which the restrictions determining the performance of the controller can be attached depending on the control problem in question. Eight embodiments of the controller are available. Thus, all control problems, even the most complicated ones, occurring in industrial processing can be solved. The controller is designed for purposes which do not require operation with standardized transmission signals.

SIEMENS

U.D.C. 621.315.221.7:669.71

HANS BORCHARDT AND WALTER THELE

Cables with Continuously Extruded Aluminium Sheaths

6½ pages, 9 figures, 1 table, bibliography

Siemens Review XXVIII (1961) pp. 160 to 166

By reason of the advantages afforded by direct extruded sheaths, cables with aluminium sheaths have found a wide field of application. This method, developed and introduced by Siemens-Schuckertwerke, has been further developed to a continuous process and the aluminium extruding press in the cable works in Berlin has been converted into a continuously operating press. A description is given of the mode of operation of this and of the advantages of direct and continuously extruded aluminium sheaths.

SIEMENS

U.D.C. 621.317.7.083.5

HELMUT KAULFERSCH AND FRANZ SCHUBERT

The New Potentiometric Recorder KOMPENSOGRAPH 192 × 288

4 pages, 7 figures

Siemens Review XXVIII (1961) pp. 149 to 153

Potentiometric recorders are gaining more and more ground in research and industry as indispensable devices for solving certain problems. The new KOMPENSOGRAPH 192 × 288 operates on the potentiometric method. Its essential mechanical and electrical construction units are of novel design. A description of the instrument is given.

SIEMENS

U.D.C. 544.64/.65 + 545.824

KURT TÖGEL

Vacuum X-ray Fluorescence Analysis for Elements with Atomic Numbers between 12 and 22

6½ pages, 13 figures, 3 tables, bibliography

Siemens Review XXVIII (1961) pp. 153 to 159

Critical factors to be considered in the X-ray fluorescence analysis of elements of small atomic numbers. Description of a vacuum spectrometer and a flow-type counter tube for measuring X-ray spectra of wave lengths up to 10 Å. Examples of qualitative and quantitative analyses. Discussion of the accuracy of X-ray fluorescence analyses and the limits of detection.

SIEMENS

U.D.C. 621.317.39:531.787:536.5:532.217

RICHARD SPIESS

New Monitors for Pressure, Temperature and Level

4 pages, 9 figures, bibliography

Siemens Review XXVIII (1961) pp. 166 to 170

Pressure monitors (up to 5,680 psig), temperature monitors (up to 700 °C) and level monitors (up to a nominal pressure of 2,275 psig) are employed to supervise the limiting values in thermal installations, particularly in steam power stations. By reason of their unitized construction, the monitors can also be used for applications in other branches of industry. The measured value is evaluated continuously and, with the exception of the reed contacts, contactlessly. The robust mechanical design and the use of time-tested electronic components ensure a high degree of operational reliability. If required, a separate power unit can be supplied to make the monitors independent of the main power supply.

SIEMENS

U.D.C. 621.316.7:621.314.7:532.217

HANS NODER

Level Control with the TELEPERM Z Controller

3½ pages, 7 figures, bibliography

Siemens Review XXVIII (1961) pp. 170 to 173

With the hitherto conventional control equipment employing relays or magnetic amplifiers it was not possible to obtain the valve positioner operating times of down to 15 seconds required in the case of level control for tanks having a relatively high throughput and a small cross-section. The use of transistor amplifier units has resulted in the development of a controller, which, in conjunction with a capacitor "brake" for positioners, can be employed for exacting level control applications. The article includes a description of a control system; with the aid of graphs, the results obtained with an experimental system are given.

For cutting out and pasting on index cards

SIEMENS

U.D.C. 621.335.3.024

WILHELM WÜSTE

New D.C. Locomotives for Double-unit Operation in Open-cast Lignite Mines

2 pages, 3 figures

Siemens Review XXVIII (1961) pp. 174 and 175

Experience has shown that locomotives whose axles run rigidly in the frame produce particularly heavy stresses on the tires and track. For this reason, the locomotives for a recent order were designed with bogies, the good curve negotiating characteristics obtaining with this type being further improved by the use of rubber suspension.
With the aid of contactor control, these four-axle locomotives can be coupled mechanically and electrically to operate as a double unit. A description is given of the mechanical and electrical design.

SIEMENS

U.D.C. 688.742.5 (436)

WILHELM FOHLER

Stage-lighting Equipment for the Passion Play Theatres in Austria

1 page, 2 figures

Siemens Review XXVIII (1961) pp. 180 and 181

The Passion Play theatres in Erl, Thiersee and Kirchschlag have been equipped with stage-lighting control equipment. This includes a tracker-wire operated dimmer board working in conjunction with single-phase Bordoni regulating transformers. In addition to this, various stage-lighting units have been installed, such as lens floodlights, reflector floodlights, footlights, borderlights and cyclorama lights.

SIEMENS

U.D.C. 654.1/.9.026:728.51(43-2.1)

HORST MOSTLER AND HEINZ HOFFMANN

Communications Equipment of the Hotel am Zoo in Berlin

1 ½ pages, 3 figures

Siemens Review XXVIII (1961) pp. 181 and 182

A description is given of the communications systems installed in the hotel and in particular of the radio program relaying system and the radio-operated staff locating system.

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